THE OPEN·BOOK OF NATURE

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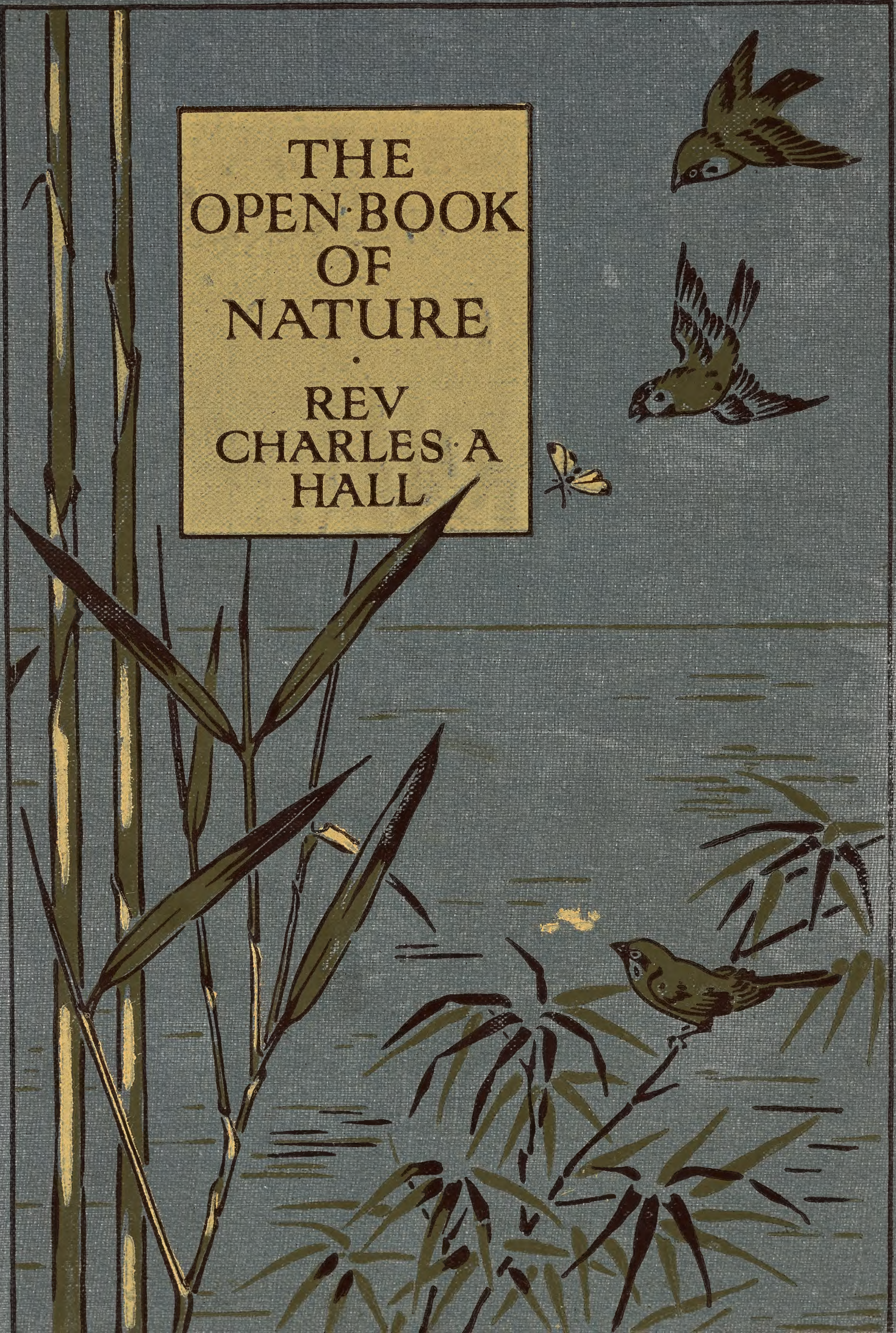
REV
CHARLES·A
HALL



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THE OPEN BOOK OF NATURE

PLATE 1

An English Woodland. A Happy Hunting Ground for the Naturalist.

THE OPEN BOOK OF NATURE

AN INTRODUCTION TO NATURE-STUDY

BY THE

REV. CHARLES A. HALL

AUTHOR OF "THE DIVINITY THAT SHAPES OUR ENDS," ETC.

CONTAINING 16 FULL-PAGE ILLUSTRATIONS IN COLOUR AND 114 REPRODUCTIONS FROM PHOTOGRAPHS, MOSTLY BY THE AUTHOR, AS WELL AS NUMEROUS ILLUSTRATIONS IN THE TEXT

LONDON
ADAM AND CHARLES BLACK
1911

10460

TO

MY TWO CHUMS

VICTOR HENRY AND HOWARD UNWIN HALL

THIS BOOK

IS AFFECTIONATELY DEDICATED

BY THEIR FATHER

PREFACE

This book has been written to stimulate Nature interest in young people, and to encourage the really practical pursuit of Natural History. I am satisfied that such a pursuit "pays" in the best sense of the term. Your naturalist is a sober, peace-loving individual; he takes pleasure in simple things, and his mind is too well occupied to admit of him drifting into evil ways. He may not gather much worldly gear, but his moral and intellectual wealth is great. I counsel parents and guardians to throw no obstacle in the way of youngsters who wish to become naturalists, but to give them all the assistance they can.

It is not improbable that many not young in years, but young in the study of Nature, may find much to interest them in the following pages. I trust such may be the case.

I am an out-and-out advocate of work in the field. I do not highly value arm-chair Natural History. It would be a clever book indeed that could teach as Nature herself can teach. But books are useful as guides, and I hope this effort of mine will serve in that capacity.

In writing, I have given the reader credit for intelligence and earnestness. I do not think youngsters like to be spoken to in namby-pamby terms, and treated as babies.

Although necessity has compelled me to touch but the fringe of the various subjects I have alluded to, I hope this book will not be regarded as favourable to desultory study. Superficial knowledge is one of the evils of the age. I stand for thoroughness, and I trust that, if any reader is induced by my words to take up a particular line of Nature investigation, he will be patient and persevering therein.

There is no disguising the fact that there is no royal road to Nature knowledge: it can be acquired only by the exercise of brains and the patient labour of years. I should be sorry if any reader were to accept this volume as a compendium of Nature. While I have doubtless given some information, I have aimed at showing how much there is to know, and what a vast field the student has before him.

I have purposely given prominence to the subject of Geology in the following pages. Geology has received scant notice in many popularly written modern Nature books: it demands a wider recognition. Perhaps it does not lend itself to popular exposition. However, I trust the simple chapters I have devoted to Geology and the study of fossils will bear fruit in an accession of young students.

One thing I insist upon : no matter how widely a naturalist may travel, or how extensive his knowledge may be, he ought to know every inch of the ground of his own district, and be familiar with its flora and fauna. I should like to see a Young People's Natural History Club formed in every parish of our dear old country. Under wise guidance such clubs might be instrumental in making a thorough Nature survey of the whole land—"a consummation most devoutly to be wished."

I launch my effort with the desire that it may succeed in the uses for which it is intended, and with the hope of some degree of popular support.

C. A. H.

MEIKLERIGGS,
PAISLEY.
March, 1911.

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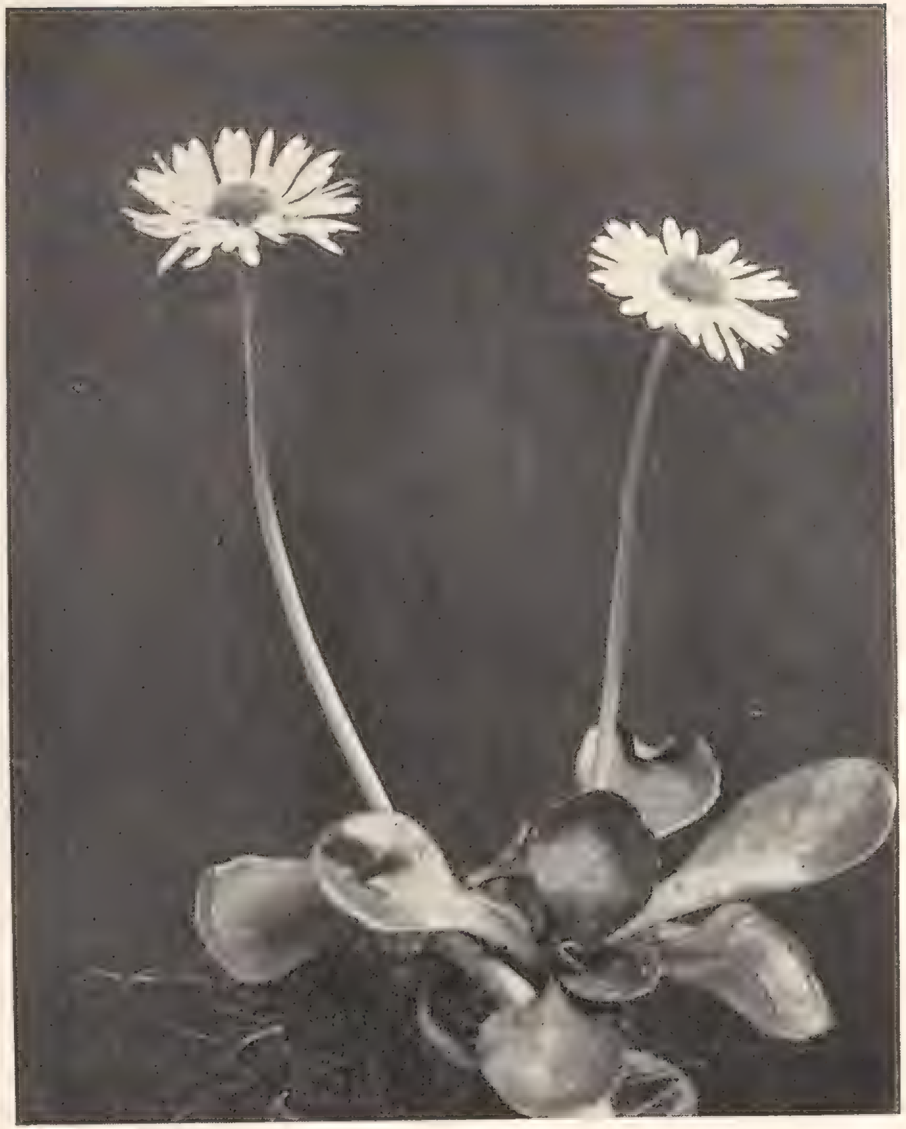
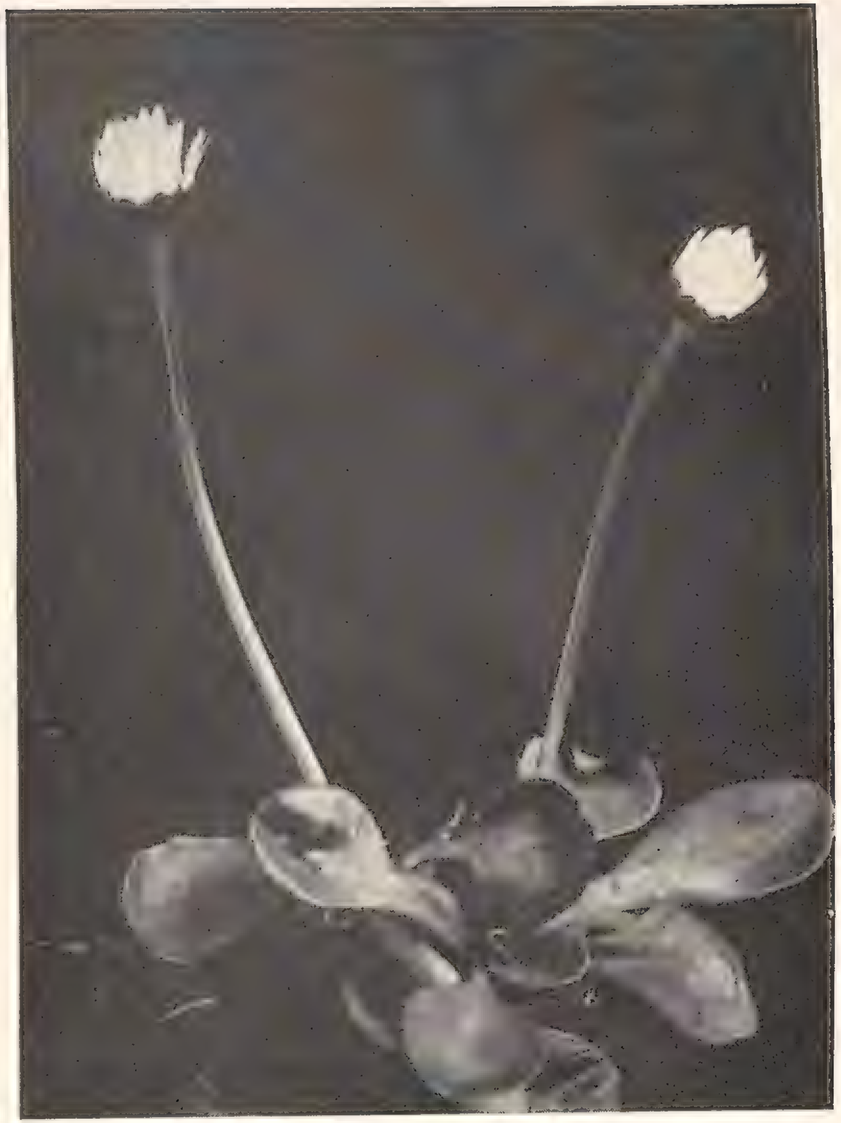
The Goatfell Range, Isle of Arran. Granite Mountains Slowly Crumbling.

PLATE 3



(*a*) Daisy Awake. *P.* 3.



(*b*) Daisy Asleep.

THE
OPEN BOOK OF NATURE

CHAPTER I

INTRODUCTORY

Although, I dare say, there will be much in this book that will prove interesting to quite grown-up folk, I am writing it specially for the young, whom I shall address in the second person. I believe all young people have some love for Nature, and some interest in fossils, birds, beasts, and flowers ; indeed, I am often much indebted to boys and girls for valuable information. If I find myself in a new district, and want to know the best hunting-grounds, say, for sticklebacks, newts, or tadpoles, I am fairly sure of getting the information I need from the first group of lads I meet ; and if I am in search of primroses, violets, ferns, or toadstools, I shall certainly meet some girls or boys who can tell me where to look for them. Now, I hope the love of Nature which young people display will never be lost or even overshadowed by other loves and interests. I am writing in the hope of increasing your interest in Nature's works, and trust that my book may be a real help and guide to you in your studies. It often happens that the study of Nature is laid aside in favour of cricket, football, hockey, tennis, and other sports. I have nothing to say against any innocent and manly game, but I do think it is a pity when these things are indulged in to the negligence of a study of Nature which, properly prosecuted, will be found to be a recreation of the highest type. Nature-study is a pursuit which calls all our faculties into action ; it makes us observe, remember, reason, and think ; it takes us out of stuffy rooms into the open air ; it makes us walk, wade, row, and even swim ; it develops inventive genius, gives us eyes to see interesting things everywhere ; it appeals to the sense of beauty, form, and colour, and, above all, makes us reverent by leading us to look up from Nature to Nature's God. There is no living plant or animal, be it never so common, that will not repay study, and provide, if intelligently observed, quite a romantic story. A spider and its habits will give us quite as much interest as pigmies or cannibals in some far-distant land ; and no more wonderful story has ever arisen out of the imagination of man than is daily enacted in the lives of ants, bees, and wasps.

The flowers, even of the commonest kinds, are quite as interesting in their habits as more highly developed creatures. What could be commoner than a daisy, but what a remarkable story it has to tell ! For myself, I have never ceased to be interested in the wonders it displays. You read about the great battles of the world's history, the terrible struggles that have taken place between man and man; you get excited about noted warriors, and heroes, and terrible tyrants, but no greater battle was ever fought by man than is being silently waged by the daisy every day of its existence, and probably no man ever was so determined to win a fight, or so unscrupulous in his methods, as this seemingly modest flower. When you know the ways of plants, as I hope I may help you to know them, you will realize that there is a strange kinship between man and the lowliest member of the vegetable kingdom; that, indeed, every living creature in common with man is engaged in the quest for habitation, food, and clothing. Nay, more than this, you will some day come to understand that the life which actuates a plant or an animal is the same life which manifests itself in a man, the difference between man and lowlier forms of life being purely a matter of organization. It is because it is the same life that moves man and animal and plant that both animals and plants are so seemingly human in their ways. The ways of plants and animals, however, are human only up to a certain point; they fall short of the morality and religion for which man is so conspicuous.

Having made mention of the daisy in a rather pointed fashion, I shall probably have whetted your appetites for its story, and I feel I must at once justify the statements I have made about this plant.

The common daisy, known also as the "gowan," and dignified by the Latin name *Bellis perennis*, is what is known as a "compound" flower. It is called "compound" because what seems to be a single flower is really a head of many flowers, or florets, all clustered together. Go out and gather a specimen, and look carefully into it ; you will be able to find one almost any time in the year. You will at once see that it has a yellow centre, and a white fringe. If you have a magnifying-glass, examine the specimen more closely by its aid. You can now see that the yellow centre, or disc, is composed of about two hundred little flowers, with their tiny yellow petals united to form five-cleft tubes, each floret being possessed of all the essential organs of a flower. The white fringe, you will find, is made up of about fifty " ray " florets, each floret being a lady flower, with a single strap-like, white, crimson-tipped petal and a pistil, or female organ.

I hope you have secured a complete plant—flower-head, root, and leaves. Notice that the stem from which the leaves spring is fairly stout and strong, and that it lives underground, sending rootlets into the earth. You may see specimens with two or more sets of leaves and flowers springing from different points of the same stem. The leaves form a neat rosette, and are generally found pressed down on to the ground, especially on lawns.

Now let our little friend tell its own story :

" Many ages ago my ancestors were somewhat different in appearance from my kind to-day. They had rather long flower-stalks, which bore flowers, each with a separate little stalk, and arranged somewhat after the manner of the flowers of the common currant, and each flower on the stalk was complete in itself.

" In those very early days of my kind there was a terrible competition for the good things of life. All kinds of plants were struggling keenly for light, and air, and food. My ancestors had to fight very keenly with other plants which threatened to smother them with their leaves, and prevent them from getting the barest necessaries of life.

"Those were terrible times. I might say that my revered ancestors were at their wits' ends to know what to do. Well, after much struggling, and as it were by chance, they hit upon a remarkable device. Other plants threatened to smother them, and they somehow learned how to pay back in kind. Originally their leaves were borne on a stem at some distance apart from each other, not in rosettes, as in my case. It happened that they had some children whose leaves grew closer together, and these children gave birth to generation after generation of other children, with leaves growing closer and yet closer together, until one season came when they actually pressed together into the form of a rosette.

"Just here the story of my kind becomes wonderful. The development of the rosette of leaves marks a great epoch in our history. Up to that point neighbouring plants threatened to smother us by growing over our heads, thus cutting off light, air, and moisture. But when my ancestors arrived with the rosettes of leaves, their rootlets pulled the stems below the ground right up to the place from whence the leaves sprang, and the leaves pressed themselves in solid circles on the surface of the ground. This new development prevented plants from growing within the immediate circle of the leaves, and secured daisy plants a goodly supply of ground room, which was also increased by the growth of more and ever more rosettes of leaves from the stems of the parent plants. Wherever my kind got a good hold they henceforth flourished.

"My family very early learned that union is strength. They saw that individual daisies could not hold their own, and that if they would succeed in life they must co-operate. So they formed colonies, not only of plants, but also of flowers.

"You will see that my compound flower-head is really a colony of little flowers. Just as in ancient times daisy leaves combined to form a rosette, and daisy plants joined to form powerful colonies, so daisy flowers gave up the idea of lonely life, and adopted the colonial practice, which you may notice is of quite an advanced nature.

"Look at my white ray florets. They are very easily seen. They serve more than one purpose; they are advertising agents; they let my friends the insects know that I am here, for some insects are very useful to me. They come to me for a little food, which I very willingly give them, and as they get their little dainties they dust themselves with my tiny pollen grains, which they carry to and leave on other daisy plants. These pollen grains are full of a wonderful life-force, which makes our seeds grow and be productive of new daisy plants. Then when night comes on, or it is a cold and cloudy day, these white ray flowers fold their petals over my yellow and more delicate florets, and keep them warm.

"My yellow florets do the real business of my life. They produce pollen and seeds, and provide for the appearance of the very many generations of daisies that will have their being when my short life is at an end. You know, we don't live for ourselves; we live for the race. We can be seemingly cruel and unscrupulous. We won't give an inch of ground to any other plant if we can avoid it, and if any plant does come within our reach we don't hesitate to kill it if we can. I know we spoil your lawns, but then we must live as well as you. Your lawn-mowers cut off our heads, but although we don't like to lose our heads, we can get on without them. We are superior to you in that respect; when your heads are cut off you die, but we have other heads in store, and even if all our heads fail us we can still produce new daisy plants by budding.

"We grow wherever we can. We like lawns, because our strongest competitors, the grasses, can't get ahead of us because of the lawn-mower. We get on well in meadows where the cattle keep the grass short and leave us alone. But we get rather a shock in hayfields, where the grass grows long and overshadows us. The shock, however, is of short duration, for when the hay is cut we do well again, and while the hay was over us we had lots of good food stored away in our thick stems.

"By the way, we have some relatives, perhaps cousins, which manage very well among the hay. They have long stems, and can raise their flower-heads to, or even above, the level of the grasses. You know my cousins well; they are quite familiar friends; you call them 'ox-eye daisies,' and those learned men, the great botanists, have given them the Latin name, *Chrysanthemum leucanthemum.*"

The daisy has not told us all its story, but it has given us enough of it to make us realize how wonderful it is. When you know more of botany, and the structure, organs, and operations of flowers, you will be able to fill in many details that have been omitted.

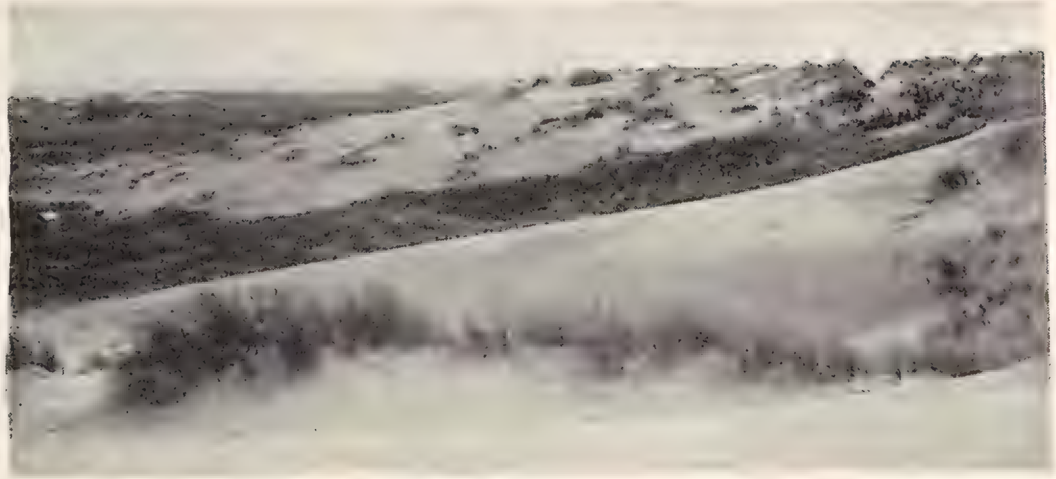
This daisy story has taken up more of our space than I wanted it to occupy, but there are some few things I must yet say in these introductory words.

I am writing with three objects in view. In the first place I wish to stimulate your love of Nature and your desire to know more about her ways. This I hope to do by telling you some interesting facts. Then I want to give you some guidance in the pursuit of your studies. I find that many young people are almost frightened by the array of subjects that are open for inquiry. The field of Nature is so vast that they despair of gaining any close knowledge, or they do not know where to begin. And, in the third place, I want you to become practical naturalists.

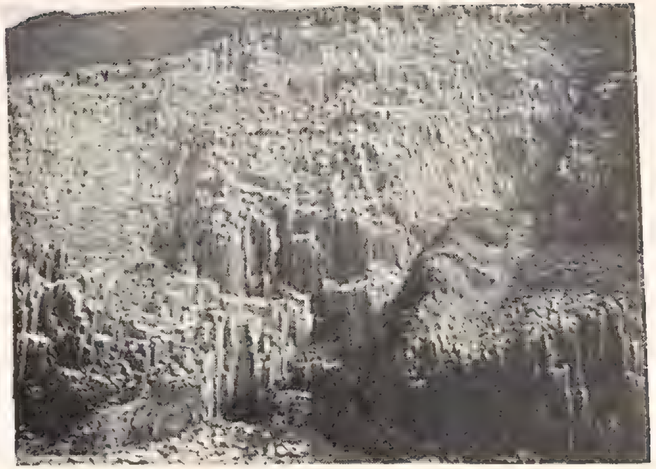
I will take it for granted that you already desire to study natural history, and wish to know where to begin. Well, begin just where you are. Go out of doors, and take note of the first natural object that attracts your attention, notice its outstanding features, its peculiar habits, and see what it does in its natural surroundings. If you don't know what the object is, ask someone wiser than yourself, consult books, and get to know all that you possibly can about it. The probability is that the first thing you notice will be something of which you know the name—a flower, an insect, a bird. When I opened

The Alltgobhlach Burn, Arran. *P.* 17.

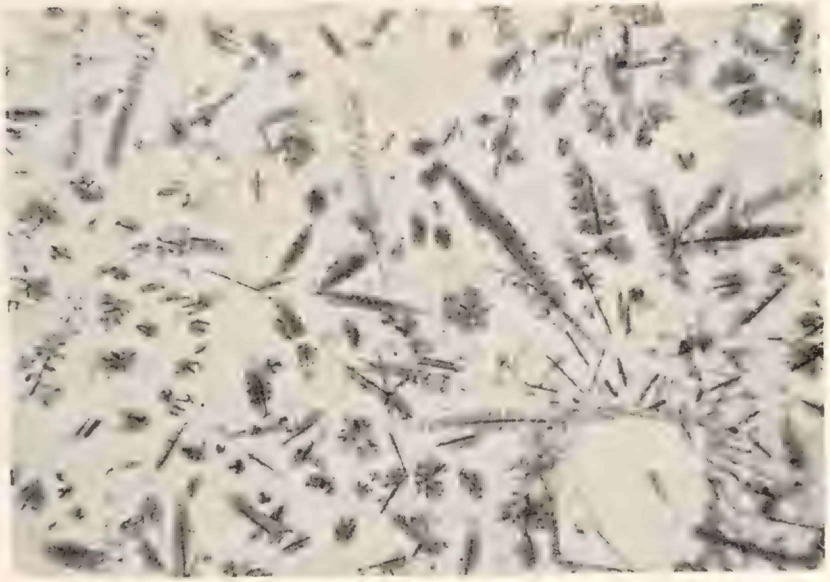
PLATE 5



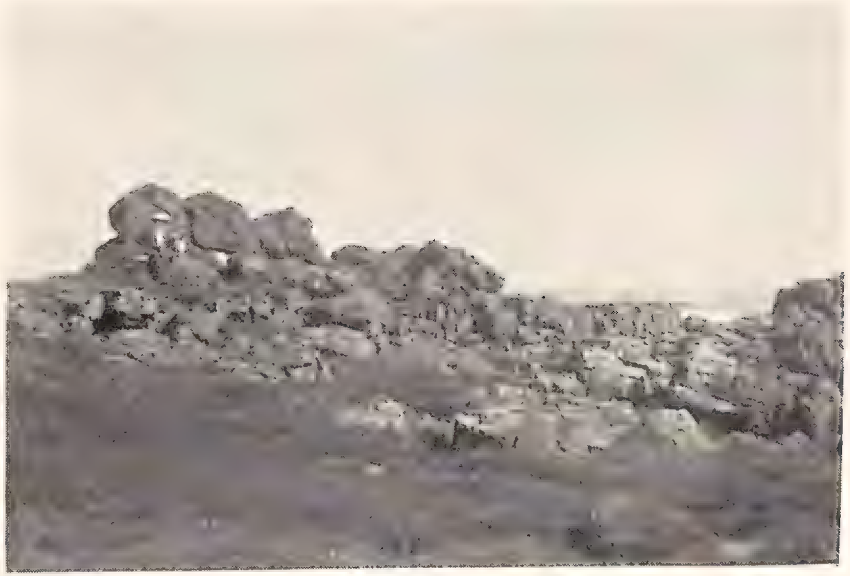
(*a*) Sand-dunes. *P.* 17.



(*b*) Columnar Volcanic Rocks. *P.* 25.



(*c*) Section of Arran Pitchstone (magnified). *P.* 25.



(*d*) Volcanic Dyke. *P.* 26.

my front-door this morning the first thing that caught my eye was a spider, which had set its wonderful net among the foliage of a hanging plant, and was patiently waiting at the end of its signal line, just as quiet as quiet could be. I watched it for a long time, and although it had set its net so cunningly and waited so patiently, it had not secured a breakfast long after my dinner was eaten and digested. It had toiled for many hours and caught nothing. It looked quite lifeless in its waiting-place, but when I caught a fly and threw it on to its web, it was on the spot in an instant. The fly I put into its clutches, however, was not to the spider's taste, and it rejected it in a most disdainful fashion. Suppose, then, that you, too, observe a spider, let it be the starting-point of your Nature-study. Ask your friends about spiders; read books that tell about spiders; find out how many kinds of spiders are known in your country, and where to look for the various species. If you have no books that help you, go to a public library, and ask the librarian for his aid. Perhaps you have a public museum near to you; if so, that is the very place you must hie to; the curator of a museum is always glad to help young students, and you may be sure he will welcome your inquiries and be of great assistance. Of this I am certain: if you are in real earnest you will get the knowledge you require "by hook or by crook," as the saying goes.

You will not have advanced very far in your study of spiders before you find them fascinatingly interesting. What you read about them will inspire you to go out and search for other specimens, and the facts you are told you will wish to confirm by practical observation. Spiders, like all living creatures, are interesting in books, but they are a thousandfold more interesting to the intelligent watcher of them in their natural surroundings. The study of one object of Nature, if properly followed, will lead to an ever-increasing knowledge of scores of other objects, to which the first one, say a spider, is related. For instance, you will soon discover that spiders set their traps for certain insects, and you will want to know something about those insects. Then you will find that spiders have enemies in certain kinds of birds, who seek them for food ; you will surely want to know all about these birds. And your reading will reveal to you what you can soon see for yourselves, that spiders are nearly related to shrimps, prawns, crabs, and lobsters. This knowledge should fire you with the desire to get information about these creatures of the sea, and the next time you find yourselves at the seaside you will be able to spend many happy and useful hours in finding specimens, and seeing for yourselves how they behave themselves. If you cannot get to the seaside, you will find preserved specimens in most museums, and, failing a museum, you can learn a good deal at a fishmonger's shop.

I need not write more on this point. I think you will see how to begin the study of Nature, and how the study of one object will lead to a wide field of pleasant observation.

I hope you live either in the country or very near to it, and can sometimes get to the seaside and the mountains. But if you live in the heart of a large town or city, you can still do some Nature-work. If you get to know the story of everything that is sold in a fruiterer's shop you will have become quite a good botanist. Go to the fishmonger's place, to the grocer's, the florist's, the bird-shops, and the public parks, museums, and libraries ; you can learn much of Nature from such sources. Try to grow a few wild flowers in pots or window-boxes ; they will provide you with hours of delightful observation and study. "Where there's a will there's a way"—there's no mistake about it. If you want to study Nature and be thoroughgoing naturalists, you will find material anywhere. Enthusiasm, determination, and common sense will carry you a long way, and enable you to accomplish great things.

The final and crowning object of this book is that it may help you to become really practical naturalists, and to do some Nature-work that will be of real service to your fellow-men. Books are very useful friends and helpers, but you must not be content to enjoy Nature through their pages ; you must use them for guidance in actual field-work. I want you to go out of doors and see things with your own eyes and form your own conclusions about them. Don't be satisfied with knowing the name of a bird or a flower ; get to know its life-story, and don't be too sure about anything said in a book until you have tested the truth of it for yourselves.

In field-work you will find yourselves attracted to particular lines of study. Some of you may feel impelled to make a special study of the rocks, and so become geologists. Others may favour the flowers, insects, or birds, and so become botanists, entomologists, or ornithologists. What is badly needed is a thorough survey of Nature in every district of our country. If intelligent and earnest boys and girls would combine to collect information about their own immediate neighbourhoods, and make good and orderly records of rocks, fossils, flowers, insects, birds, rainfall, temperature, and so forth, such a survey might soon be an accomplished fact.

Personally, I move about the country a good deal, and see Nature under many aspects, but I often say that if I could never get beyond a two-mile radius from my house, I should still have an inexhaustible field for investigation, and if I were confined to my own garden, it would provide me with Nature-study to the end of my natural life. Boys and girls, especially boys, sometimes think that to be naturalists they must travel thousands of miles and see the wonders of foreign lands. Truly, many great naturalists have been great travellers, and their travels and observations have enriched our knowledge. But a boy or girl can be an excellent naturalist without going a mile in a train or a knot in a boat. Know your own districts thoroughly, that's my advice, and if you act upon it I am sure you will thank me for it some day.

By the way, I shall be obliged to use some rather big words and occasional scientific terms in this book. I shall also give you the scientific names of most objects as well as their popular ones. I think my readers will want to gradually get into the way of really accurate description, and to do this they must use scientific language. I hear and read a good deal of silly palaver about simple language as contrasted with technical terms. Well, technical terms can be overdone, but they have their uses, and we must try to understand them and use them as occasion demands. If you have any difficulty in understanding any terms that I use, please refer to the Glossary which I append to this volume ; in it you will find a lot of terms defined and explained.

CHAPTER II

THE GROUND OVER WHICH WE WALK

It is raining to-day, raining in torrents, but although it is not a comfortable day on which to go out, I must put on my mackintosh and go over the way to see some work that the rain is doing. Near to my house there is a road which has not been completed; it is roughly made of cinders, which soon get reduced to dust, and on wet days it becomes soft and spongy. Come along with me so that I may give you some idea of the power of running water, and the important part it has played in the history of the earth. We are going to have a little lesson in geology, which you probably know is the science which treats of the earth and its contents—tells us about rocks and how they are formed, and of all the wonderful forces that have been at work in making the earth what it is to-day.

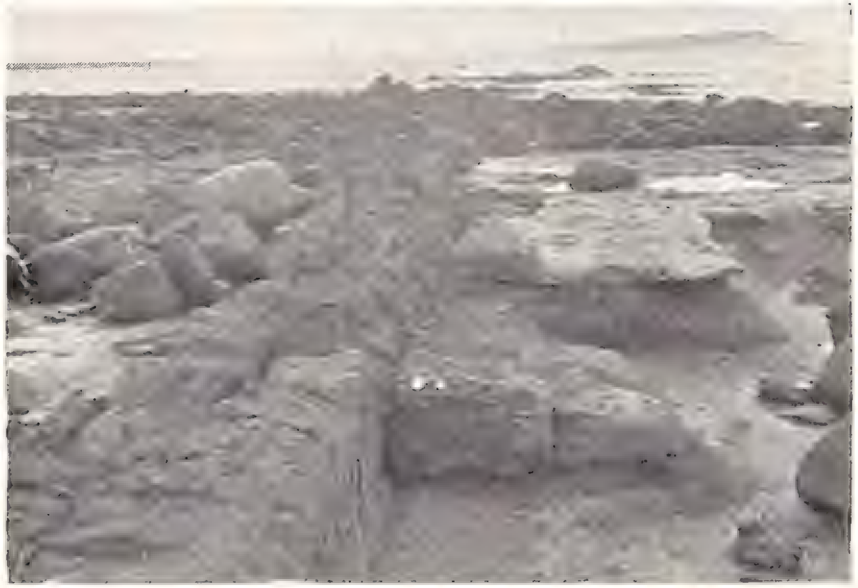
The road, you will notice, rises gradually from where we stand towards the south. On the west side of the road you see there is quite a steep, uncultivated grassy bank. The heavy rains of the last few hours have saturated the surface of the bank, and water is pouring down in little runnels, and gathering into a pool on the road. The water that comes down the bank is muddy, and the muddiness is due to little particles of soil which the water has picked up, and is carrying along " in suspension," as the geologists say. Look at the bottom of the pool that has been formed ; towards the middle you will see a very thin layer of mud over the cinder-grit. Of course, you can easily see how the mud came there ; it is a collection of the fine particles of soil that have been carried by the little streams from the bank, and dropped on to the bottom of the pool. Now, if the pool were to remain for some years, and if the streams continued to deposit little particles of soil in it, the mud would get thicker and thicker. Suppose the mud were deposited at the rate of only a twentieth of an inch per month ; in the course of five years a thickness of three inches would be accumulated, and in a century the deposit would be vastly increased.

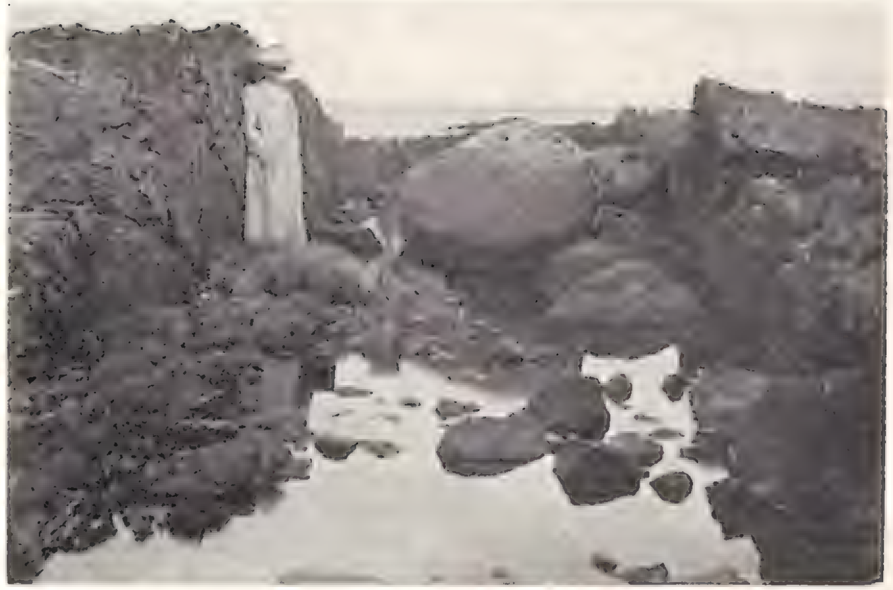
There is an overflow from the pool. The water is not scattering over the road, but is making a crooked channel for itself through the soft cinder-dust. The little stream is rushing at high speed down the sloping road towards a drain. Ten hours ago the road was almost smooth, but now the water has broken its even surface, and just where we stand it has made a channel quite six inches deep. Come to the bottom of the road where the water enters the drain. Just round the grating, which is a little higher than the road, there is a collection of mud and cinder-grit ; it is material from the road which the stream has carried away in making its channel, and deposited where you see it. I calculate that this deposited material will weigh at least fifty pounds, and we can realize that quite that weight of stuff has been moved from the road by running water in a few hours. If the process were to go on at the same rate for a few years, there would be little of the road left—the grit would be washed from its present position, and laid down elsewhere. The road-menders, however, take care that more cinders are laid on the road from time to time, and thus the loss is made up, and the accumulated deposit is removed by the cleaners.

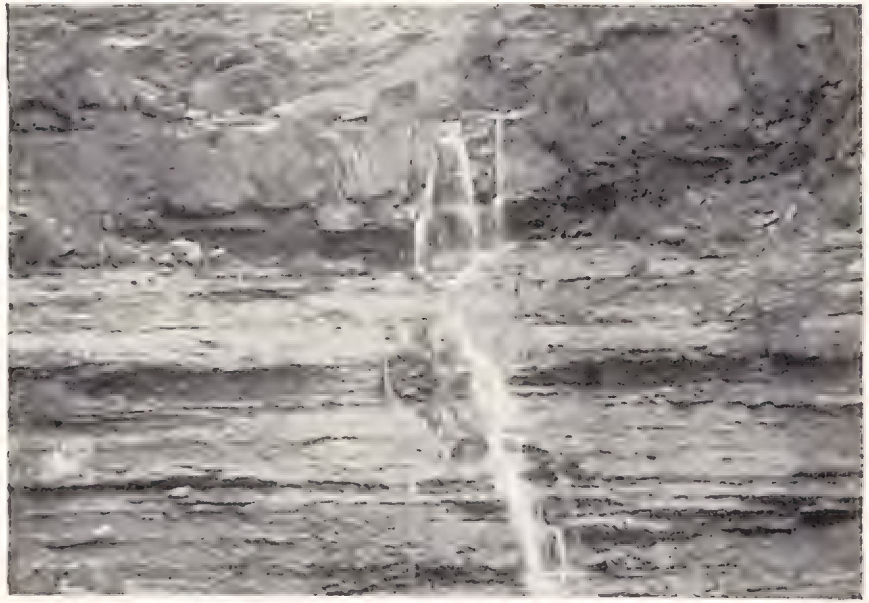
I would have you observe, also, what a cleanly cut and neat channel the little stream has made. There it takes a straight course for a few feet, and the sides of the channel are vertical and cliff-like. If you were no bigger than a cockroach, and were at the bottom of the channel, the sides would appear like great precipices. There is a bend in the streamlet, and on the right side the water has carved a little cliff, while on the left, in the angle of the bend, it has formed a gently sloping deposit of fine grit.

Loads of coarse cinders are spread over this road in winter-time. The cinders are full of little holes, and these get filled with water during rainy periods. When frost comes, the water in the cinders freezes. When a thaw follows, the cinders break up into fine grit, and the road becomes very muddy. How does this come about ? Well, you know water expands when it freezes, and the frozen water in the coarse cinders breaks them up into small particles, which, however, hold together so long as the frost lasts. When the thaw comes the particles are separated, the coarse cinders are thus reduced to fine grit, which, soaked with the thawed water, makes a most objectionably dirty road.

PLATE 6


(*a*) Volcanic Dyke (white spots) and Hardened Sandstone. *P.* 27.


(*b*) Igneous Dyke, weathering quicker than Hardened Sandstone. *P.* 27.


(*c*) Volcanic Sill in Sandstone, causing Waterfall. *P.* 27.

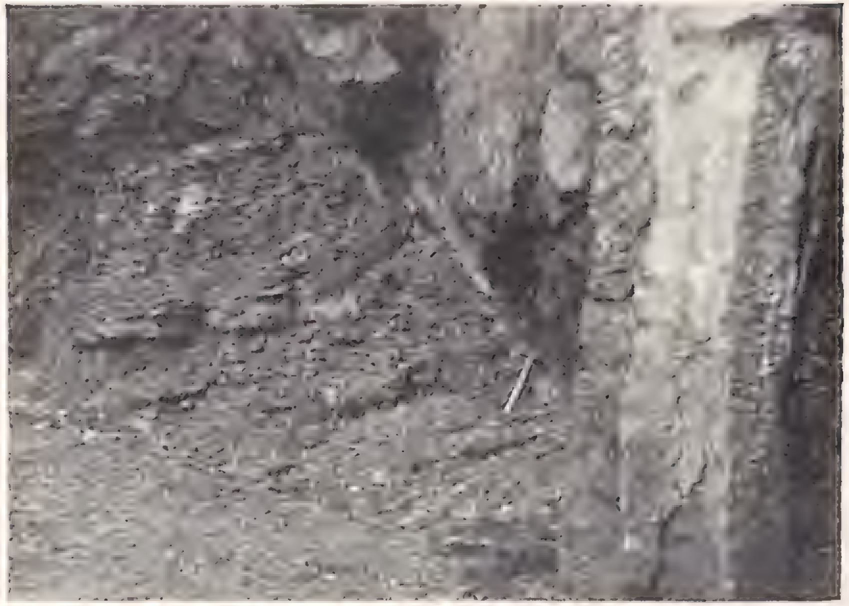
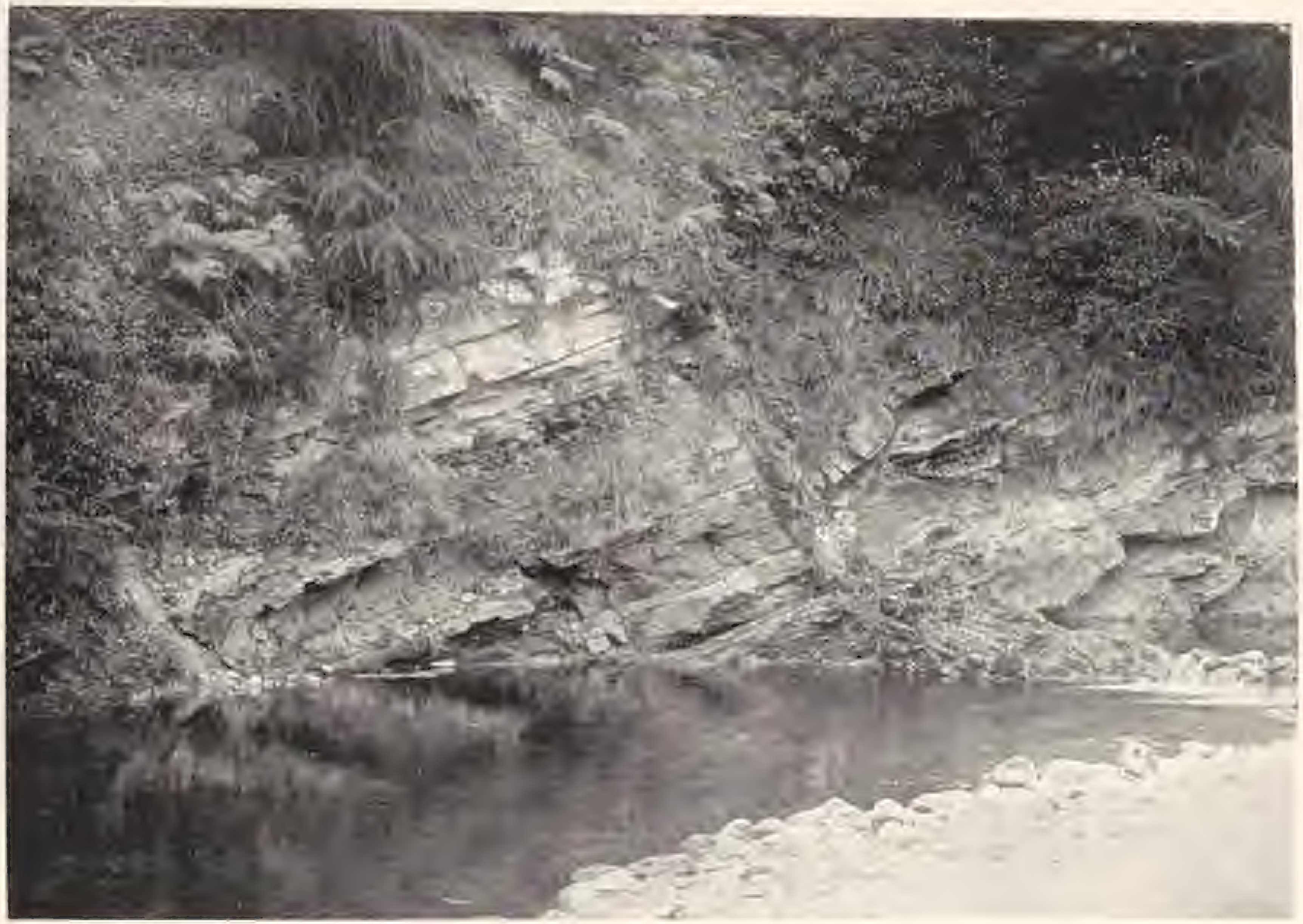

(*d*) Example of "Fault." *P.* 35.

PLATE 7



Dipping Strata, Kilmorie, Arran. *P.* 36.

Sometimes a dry windy day follows a heavy rain, and the fine deposits of the streamlets are dried until they become dust. The wind picks up the dust, scatters it over gardens and fields, and piles some of it up in corners.

Now, I have called your attention to these simple facts in order that you may realize some of the forces that have been at work all over the world for ages upon ages, and have been largely responsible for making the earth what it is at present. Just as streamlets in rainy weather wear away this road, carry away its material and deposit it elsewhere, so running water in past ages has carried away whole land surfaces, and placed their material in lakes and seas. Running water has changed the geography of the world over and over again. It has removed mountains and thrown them into the sea, and its deposits have been raised out of the sea into new land surfaces. Frost has been the means of breaking up solid granite into small particles, and water has carried these particles away. Wind has lifted thousands upon thousands of tons of sand, and raised it into sandhills.

I was staying in the island of Arran in August, 1910. It was the wettest August we have had for many years. But the rain did not spoil my holiday; on the reverse, it taught me some very enjoyable lessons. On Plate 4 I give you a picture of the lower portion of the Alltgobhlach Burn, which runs its picturesque and musical course down a precipitous hillside on the north-west of the island. It rises some two thousand feet above sea-level—right among some granite hills. In the picture it looks peaceful and harmless enough, just as it is in dry weather ; but you should see it during heavy rains, as I saw it that August. On the 20th of the month it was no babbling brook, but a mighty torrent. It rushed at great speed down its steep and rugged course into the sea. Its waters rose rapidly, so rapidly that a bridge was in imminent peril. Such a churning, whirling, foaming, boiling, toiling, and thundering torrent must be seen to be appreciated. One could see its course in the sea, at least half a mile of a clearly defined course of fresh water among the salt. As the torrent rushed along, it picked up huge boulders and hurled them against one another with terrific force and the noise of thunder. It tumbled boulders over and over, urged them along, and piled a lot of them up, so that they formed a bar where the burn met the sea. The torrent rose higher and yet higher, ever urging on more and more boulders, and occasionally one could see a boulder of big size cannoning against the newly formed bar, and literally leaping out of the burn into the sea. It was a sublime sight, and one never to be forgotten. The burn must have moved thousands of tons of material in a few hours, wrested it from the land, and hurled it into the sea.

Not many years ago the same burn carried away a bridge, and washed out twelve feet of a bank near its mouth, removing hundreds of tons of earth and stones in a second or two. There is ample evidence that this burn has changed its course several times. If you follow its present course up into the hills, you will find it descends in beautiful cascades through deep ravines, that here and there are big waterfalls, one of them having a sheer drop of some eighty feet. Under the falls are deep pools, beloved of trout, and these pools have been worn out of the solid rock by the falling water. The bed of the burn is strewn with rounded granite boulders, stones which have been torn from the hills and worn down into their rounded form by constant grinding in the stream. The banks of the burn in some places are almost vertical cliffs, naturally decorated with innumerable ferns and other vegetation. Now, mark you, the burn has made its own course ; it has eaten into the rocks, carved out its ravines, made its lovely cliffs, hollowed out its deep pools, strewn the boulders along its bed, and carried millions of tons of material to the sea without the aid of engineers and steam navvies. A great part of the most majestic scenery of the world has been made by the labours of running water.

I hope I am not wearying you. I want you to look about you with eyes wide open for examples of the wonderful work of running water, and frost, and wind ; and I want to make you understand that these are some of the agents that have destroyed continents, and built up new ones from the materials of the old. There is no waste in Nature, no real destruction. What seems to be destruction is simply rearrangement.

Let us go back in imagination to a very remote past ; to a stage in the history of the earth when it was a globe of fire-formed or igneous rock, covered everywhere by a warm, shallow sea. There were no land surfaces then, no torrents, no sands, clays, or muds. The rains pelted the surface of the sea.

Note that all the rocks of the earth at that period were purely igneous.

A time arrived when there were internal disturbances. Perhaps the earth contracted, as it might naturally do with the loss of some of its heat. Notice how an apple contracts and wrinkles when it gets old and stale ; its surface becomes covered with wrinkles and ridges. As the earth cooled and contracted it also became wrinkled, and ridges were formed. In that way land was raised out of the sea, and the first continent was formed ; perhaps it had a chain of mountains. The igneous rocks were thus raised in some part out of the sea ; rain fell upon the new land surface, rivers and lakes were formed ; changes of temperature giving rise to expansion and contraction of the various minerals of which they were composed, caused rocks to break up, wind scattered dust, and the streams carried boulders, sand, and finer particles of stuff into the lakes and the sea. In the course of ages the mountains were greatly reduced, but in the sea there was a vast accumulation of deposited material. This material solidified into rocks, say sandstones ; then further earth movements raised the water-formed rocks out of the sea, and they became a new land surface. This is some of the work that Nature has been doing for millions of years. Rocks that are formed in the way I have spoken of are known as " sedimentary " rocks.

When land was raised out of the sea, it suffered the ravages of the sea itself as well as the wear and tear caused by running water, wind, and changes of temperature. You will be able to realize what the sea can do to its coasts if I remind you of some of its work accomplished within quite recent times.

A map of the coast of Yorkshire, drawn in 1850, compared with a map made forty years later, shows that from the coast south of Bridlington the sea has removed a strip of land nearly three miles long and one hundred yards from the old cliff inwards. From Flamborough Head to Spurn Point the land is being removed at the rate of about two yards per year. In the course of centuries several towns and villages have disappeared. Ravenspur, where Henry IV. landed in 1399, has completely gone. Nine or ten centuries ago Dunwich, on the coast of Suffolk, was a flourishing city, but by 1349 the sea had swamped a great part of it, and now its chief remains are the ruins of a lonely church resting perilously on the edge of a cliff. Perhaps you have read the story of lost Lyonesse, a portion of land between Land's End, the Lizard Point, and the Scilly Islands, which has disappeared under the sea. At a not very remote period Great Britain was continuous with the Continent ; the North Sea, the English Channel, and the Irish Sea did not exist ; but in course of time the sea made its way upon the land, and surrounded our country. Now it is trying to wash our land away, and it is calculated that Britain and the whole of Europe are being worn away by running water, chemical action, and the sea at such a rate, that if the wear and tear continue they will have entirely disappeared in less than a million years. This seems to be a melancholy calculation, but you and I will not be here to see the end, and in such a length of time things might happen to raise our land farther out of the sea, and even to bring a new continent into being.

Many young people seem to be under the impression that great upheavals and tremendous earthquakes are principally responsible for changes in the earth's surface. As a matter of fact, water has done far more than they ; it has reduced mountains, hollowed out ravines, laid down fertile plains, made sheltered valleys, and deposited the rocks of great continents. The earth movements which have raised land out of the sea have been of a very gradual kind, occupying ages. Nature does her grandest work little by little.

In addition to the rocks which have been formed by fire and deposited by water, there are other rocks formed by chemical agency, others known as "organically-formed" rocks, and still others which are called "metamorphic." Perhaps I shall help you if I enumerate and describe the various rocks as follows :

1. IGNEOUS ROCKS :
    - (*a*) Plutonic.
    - (*b*) Volcanic.
2. STRATIFIED ROCKS :
    - (*a*) Sedimentary Deposits.
    - (*b*) Chemically-formed.
    - (*c*) Organically-formed.
3. METAMORPHIC ROCKS.

The IGNEOUS ROCKS have been formed from the molten material of the earth's original substance ; they are generally crystalline, and exist in large unstratified masses. They bear no fossils. They occur either as plutonic rocks, or volcanic.

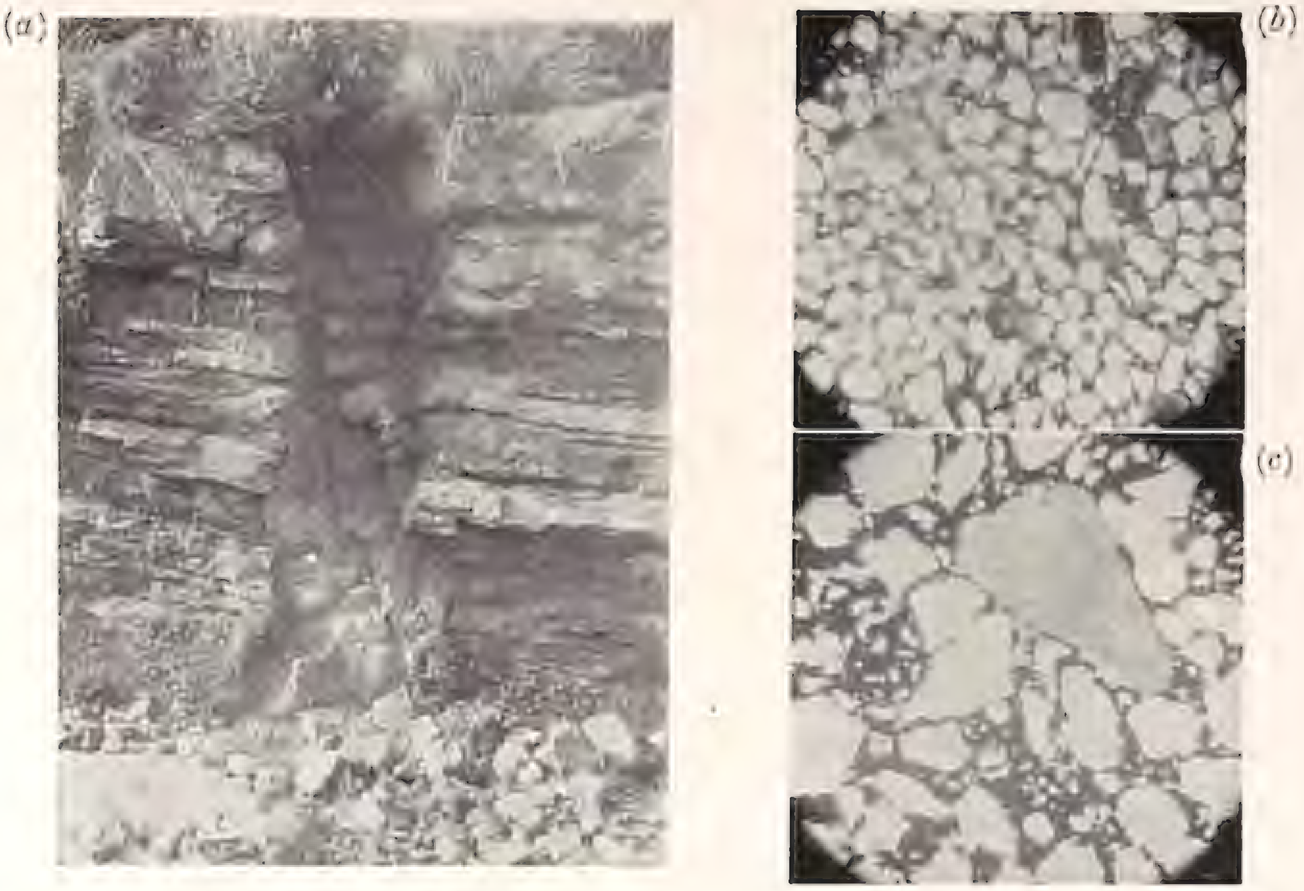
The *Plutonic* rocks are those which have cooled and become solid under the surface of the earth at great depth. Plutonic rocks are highly crystalline. Rocks which have cooled slowly are always more crystalline than such as have cooled quickly. In this respect they are like some substances which form large crystals if their solution is subjected to slow evaporation, and small crystals if evaporated quickly. You might make a very strong solution of alum, and illustrate the principle for yourselves. Apply the heat of a spirit-lamp to half your solution so as to cause speedy evaporation ; small crystals will result. Allow the remaining half of your solution to evaporate without heat in a cool place, and you will, after a time, find much larger crystals. You may rest satisfied that a highly crystalline igneous rock, like granite, may always be called "plutonic" ; it has been formed at great depth beneath the earth's surface. Granite is a very good and fairly easily known example of a plutonic rock. It is composed chiefly of the minerals known as quartz, mica, and felspar.

Secure a specimen of granite, and examine it carefully ; look at it through a good magnifying-glass, which no serious naturalist is ever without. You will see some oblong, white or pinkish crystals. These are composed of felspar—a word derived from the German *feldspath*, meaning rock-spar. See how these crystals glisten. Now look in the little mass of rock for mica crystals. These may be silvery white or bronzy black, and they are hexagonal — *i.e.*, six-sided — in shape. With the point of your knife you can split these crystals, and break layers of them away in thin six-sided plates. Further examination will show you that the crystals are set in a glasslike substance: this is quartz. But I must not tire you with too many details; what I want to do now is simply to arouse your interest in the rocks, give you some general ideas about them, and encourage you to study books that are devoted entirely to the science of geology. I ought to add that plutonic rocks are named after Pluto, the mythical god of the lower regions.

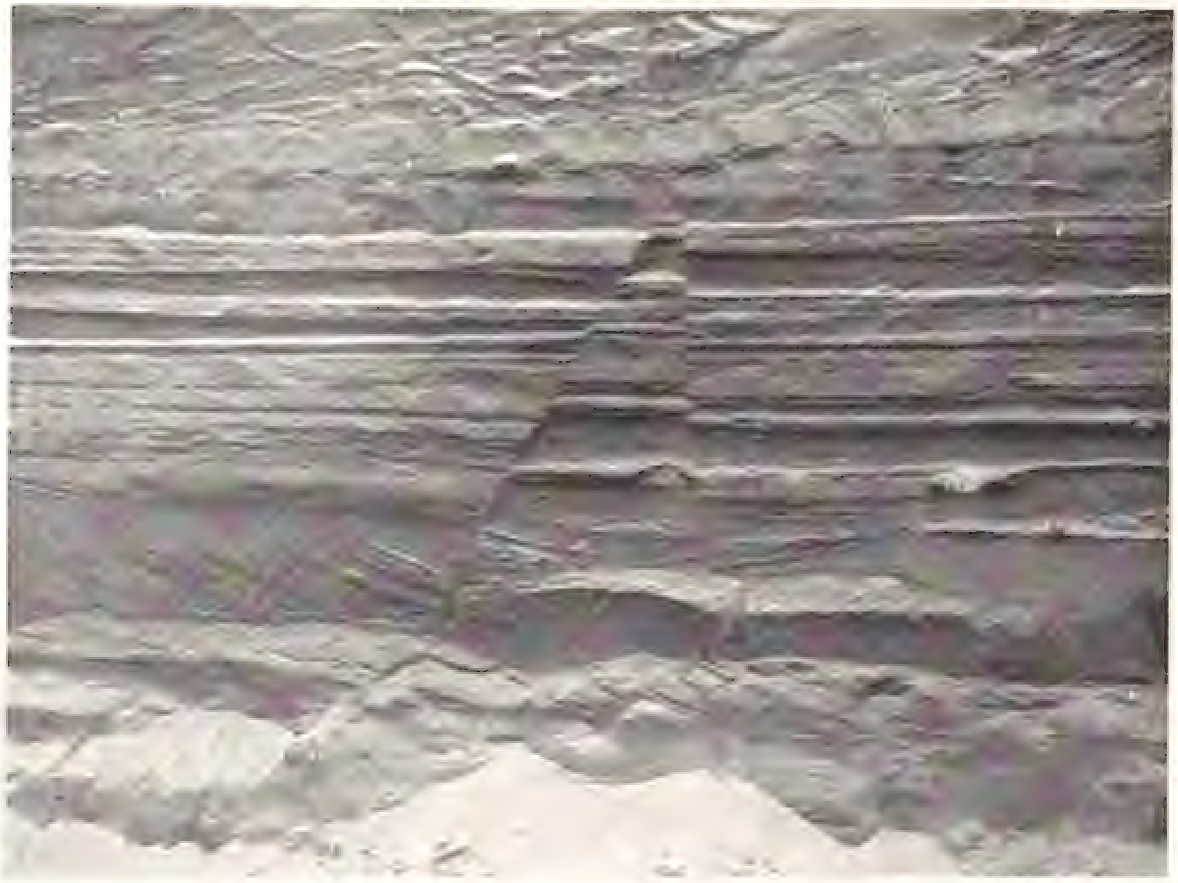
It may be asked why plutonic rocks, such as granite, so often appear on the surface. If they were formed at great depth you might naturally think they would always be found deep down in the earth. A little thought will soon remove your difficulty. I have spoken of earth movements by which land surfaces are elevated, and sometimes depressed. When land surfaces are raised they are, of course, exposed to heat and cold, frost and wind, chemical action, and the ravages of running water. By gradual upheaval rocks which were formed thousands of feet beneath the surface of the earth may be raised to a great height above sea-level. Then the stratified rocks covering, say, the granite, in the course of ages of wear and tear are removed, and the underlying granite is laid bare. Large areas of granite and other plutonic rocks have been uncovered in this way, and they in their turn are being gradually worn away.

The igneous rocks called *Volcanic* differ from the plutonic in that they have issued from the bowels of the earth as lavas, and have become solid at or near the surface. Both volcanic and plutonic rocks

PLATE 8.

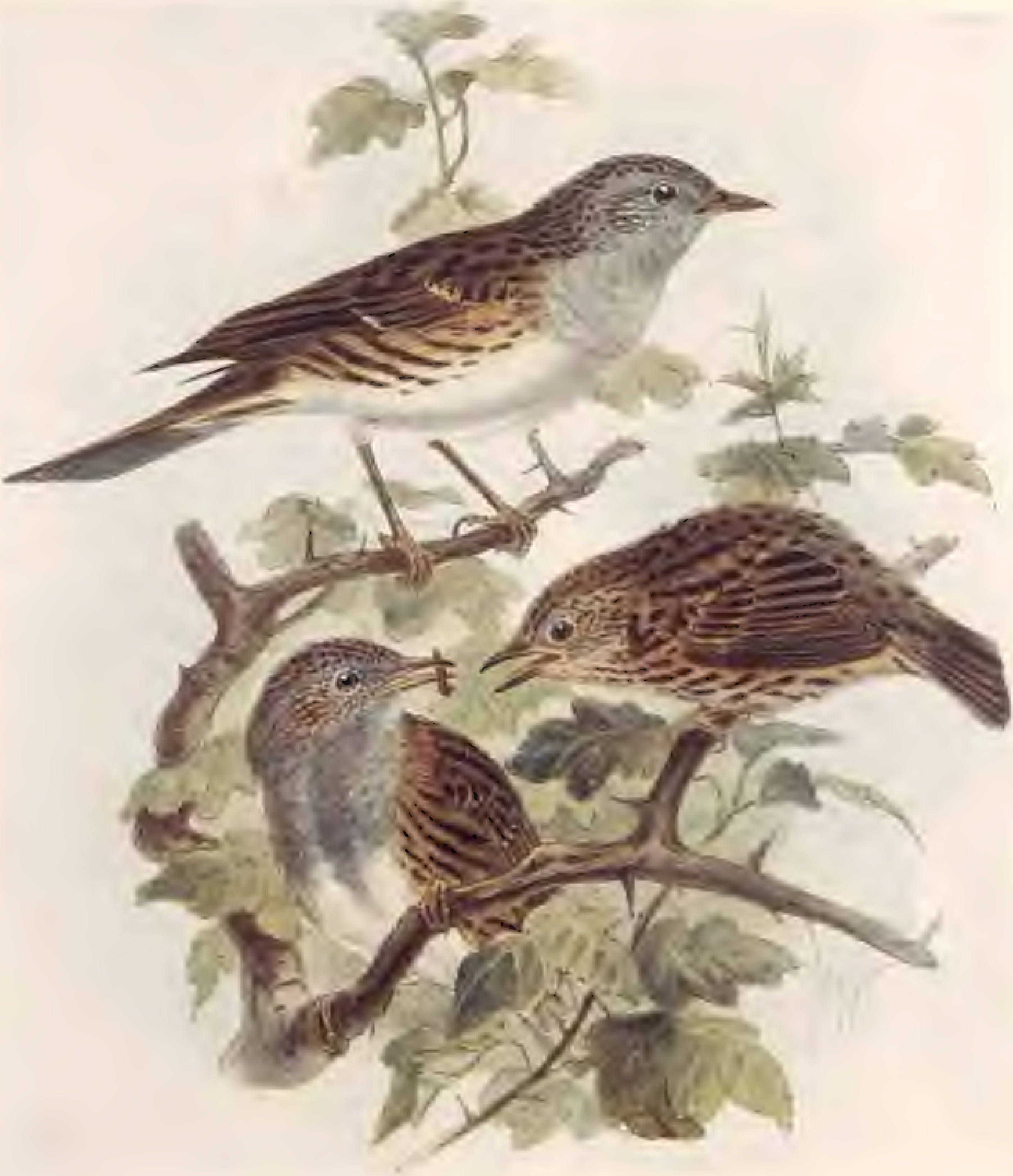


(*a*) Volcanic Dyke in Triassic Strata, S. Arran. *P.* 27.
(*b*) Section of Sandstone (magnified). *P.* 29.
(*c*) Section of Breccia (magnified). *P.* 30.



(*d*) Double Fault in Stratified Sand.

PLATE 9



Hedge Accentor. *See page* 149.

have probably originated from the same source, having issued in a molten form from a great depth in the earth ; but they present different appearances, because the one set cooled near or on the surface, and the other set at great depth. Both kinds of igneous rocks are closely alike in respect to the chemical elements they contain. Many lavas are quite glassy in structure, and such must have cooled very rapidly. We may secure a piece of pitch-stone as an example. This looks like bottle-glass, and seems to contain no crystals, but when a very thin slice is examined under the microscope some feathery crystals may be detected in the glassy base (see Plate 5, *c*). Other lavas are like masses of almond toffee, being composed of light-coloured minerals set like nut-kernels in a base of darker rock. Pumice-stone is of volcanic origin, and its form is due to the action of steam or gas on molten rock. The steam or gas made the liquid lava frothy, and it cooled as a spongy mass, full of cells. Good examples of volcanic rocks are seen in the famous Giant's Causeway in Ireland, and Fingal's Cave in Staffa. The lavas there in cooling have shrunk into magnificent six-sided columns.

Much can be learned about ancient volcanic activity from the manner in which existing volcanoes behave themselves. Vesuvius, Etna, and Stromboli, have taught us some valuable lessons, but as I cannot devote the whole of this book to geology, I must pass them by with simple mention. We have no active volcanoes in Great Britain now, but we have abundant evidence of great volcanic activity in past ages. You can find this evidence in massive areas of ancient lavas, such as I can see through my study window at the present moment. I look upon the Renfrewshire Hills, with their greatest height, Misty Law (1,663 feet) in the distance. These hills are all the result of volcanic activity in a past geological epoch ; they are built up of a succession of lava-flows from some ancient vents.

Volcanic rocks also occur as "dykes" and "sills." Dykes have been formed by molten stuff rising from the deeps of the earth in times of volcanic activity, and filling fissures in the crust. You may observe dykes of volcanic origin filling fissures in rocks that were formed in water. Sometimes the dykes stand out like long walls of various thicknesses, and their outlines and direction can be traced for miles. Softer sandstones in the fissures of which dykes have been formed often wear away, or "weather," as

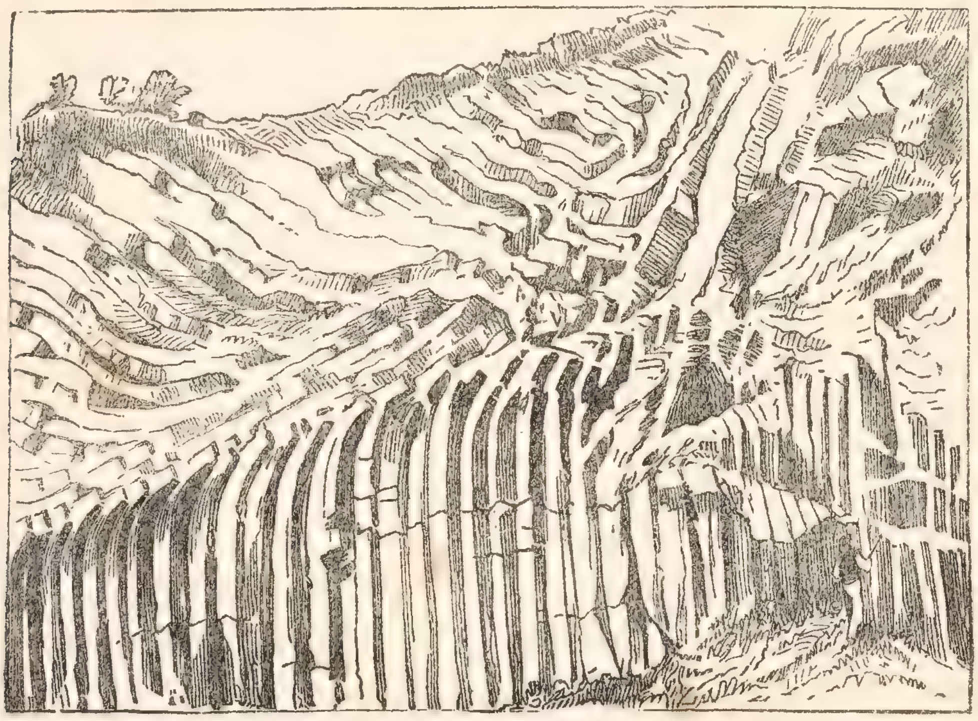


FIG. 1.—SKETCH MADE FROM PHOTOGRAPH OF QUARRY AT POUK HILL, STAFFORDSHIRE, SHOWING IGNEOUS ROCK (BASALT), WHICH IN COOLING ASSUMED A COLUMNAR STRUCTURE.

some say, much more rapidly than the harder volcanic material of the dykes, and so, after ages of wear and tear, the dykes appear like rugged walls. In other cases the molten lava has hardened sandstone by its intense heat—turning it into *quartzite*—and then the material of the dyke is often softer than the rock in its close neighbourhood. In consequence of this the dyke weathers quicker than the rock through which it runs, and the dyke is evident principally by the mould in which it was formed. Reference to illustration on Plate 6, *b*, will help you to understand what I am describing far better than many words of explanation. Dykes, it should be mentioned, are always vertical, or nearly so. Sills are sheets of volcanic material which has not made its way to the surface, but has forced itself between layers of rocks and there solidified. Such sills are sometimes discovered in districts of past volcanic activity when railway cuttings are made, or stone is being quarried. Sills are not upright like dykes, but horizontal or inclining thereto.

The igneous rocks are also spoken of as *Primary*. They were first in the field, so to speak, and they have provided the material from which the other rocks, called *Stratified* or *Secondary*, have been formed.

The STRATIFIED ROCKS, I find, interest young observers much more intensely than the igneous, and they may well do so, seeing that they contain fossils. There must, indeed, be something very far wrong with the boy or girl who is not curious about a fossil, for is it not a record in stone of some creature, or plant, that existed perhaps millions of years ago ?

The stratified rocks are called " secondary " because their material has been derived originally from primary or igneous rocks, and they are called " stratified " (Latin, *stratum* = strewn out) because they occur in layers and beds. The accompanying diagram (Fig. 2) will enable you to form an idea of the appearance of stratified rocks.

Stratified rocks have been laid down as *Sedimentary Deposits* by the agencies already written about at some length at the beginning of this chapter. These deposits are found as sand, such as is seen at the seashore, or in sand-dunes, or in the great deserts of the world, and also as gravels, sandstones, grits, conglomerates, breccias, muds, clays, claystones, slates, marls, and loams. Let me briefly describe these different deposits :

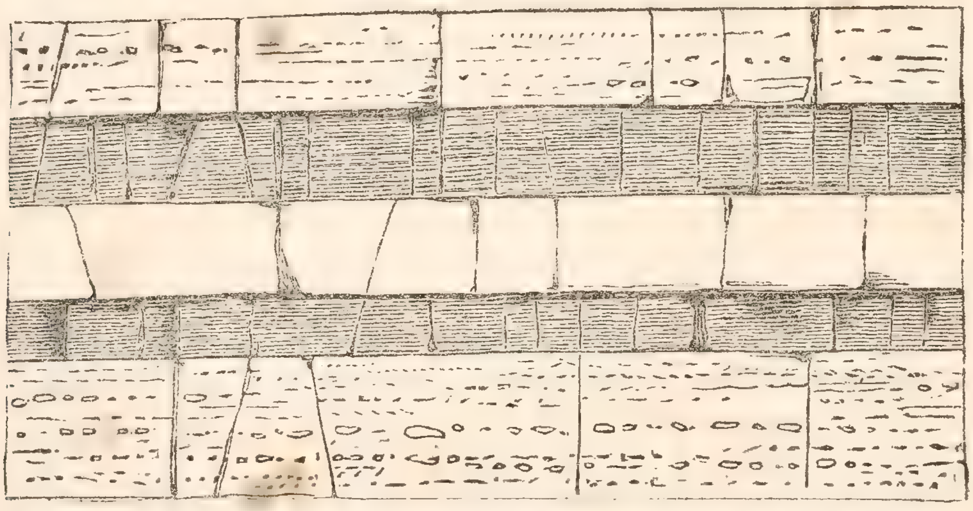


FIG. 2.—DIAGRAM REPRESENTING STRATIFIED ROCKS.

Top and bottom strata = sandstones, the two dark layers = shales, and the centre bed = limestone.

Sand is commonly formed of worn grains of quartz derived in the first instance from the wear and tear of primary rocks. Examine any sands you can get samples of under your magnifying-glass. Some samples may show well-rounded grains. These will probably have been water-worn. Other samples will contain angular grains. These give evidence of rocks broken up by quick changes of heat and cold, their little particles having been heaped together by wind. Such sands are common in dry climates. Other sands are composed of particles of carbonate of lime, derived from broken-up shells, corallines, and the limy remains of some seaweeds. These sands occur on the beaches of the coral islands of the Pacific.

Sandstone is sand cemented so that it has become a solid rock. The material which cements the grains together may have been laid down in water with the sand itself, or else have been introduced by water at a later period. The cement which binds the grains of sand in sandstone is of various composition. Some of it is a sort of clay, or it may be carbonate of lime, or a compound of iron or silica.

Gravel consists of small pebbles that have been worn and rounded by the action of water. The pebbles may be rounded portions of any kind of rock, but they mostly consist of quartz, which, being hard and durable, can more readily sustain the constant grinding to which it is subjected on shores or in fast streams. When pebbles are larger than a chestnut, and they are gathered together as on a sea-beach, they form *shingle*.

Grits are rocks formed of larger grains than those which enter into the composition of sandstones. They are practically sandstones, composed largely of coarse and sometimes sharp and angular grains of quartz. As you become more skilled in geology you will know something of the Millstone Grit.

Conglomerate is a rock composed of gravel and shingle cemented together by a paste, which may be a kind of clay, or a natural mortar of sand and lime. Conglomerate is sometimes called " pudding " stone.

Breccias (pronounced *bretchia*) are rocks formed of angular fragments such as are found in heaps of material lying at cliff bottoms. The angular fragments in breccias cannot have been subjected to much movement, or they would have been rounded like pebbles that are water-worn. So when you find breccias you will know that the materials of which they have been formed had their original position near to or at the place where the rocks are now situated.

Clay, as you know quite well, is an exceedingly useful sedimentary deposit. Where would our bricks, tiles, and drainpipes be without clay ? And what should we do for crockery ? Clay is usually deposited as mud on the floors of seas and lakes. It is composed of exceedingly fine particles of various materials, such as felspar and quartz. These particles, the fine dust formed by wear and tear of rocks, are carried in suspension in water to great distances. A running stream carries heavy fragments short distances ; it washes sand to greater distances, and the finest particles of matter, which slowly drop to the bottom of seas and lakes as mud, and become clay, are carried farthest of all. When you moisten clay it becomes soft, and it can be moulded to any shape. Mix clay with water, and you have mud. Clay under heavy pressure becomes very compact, and forms a rock known as *Mudstone*, or, as it is often called, *Claystone.* Claystone must be ground to powder and moistened before it can be moulded like common clay. Clay is often found converted into *Shale,* in which case it has been hardened, and can be split up into very fine plates. When clay rocks are subjected to great compression they may become *Slates.* Clay mixed with lime forms *Marl,* and sand and clay become *Loam.*

I do not propose to write at any length about *Chemically-formed Rocks,* lest I should tax you overmuch. As their name implies, they are formed or deposited by chemical action, and to understand their nature and history you must have a knowledge of chemistry. These rocks include some forms of limestone, as well as gypsum, rock-salt, ironstone, and vein-quartz. They are important to the human race on account of their utility in our manufactures.

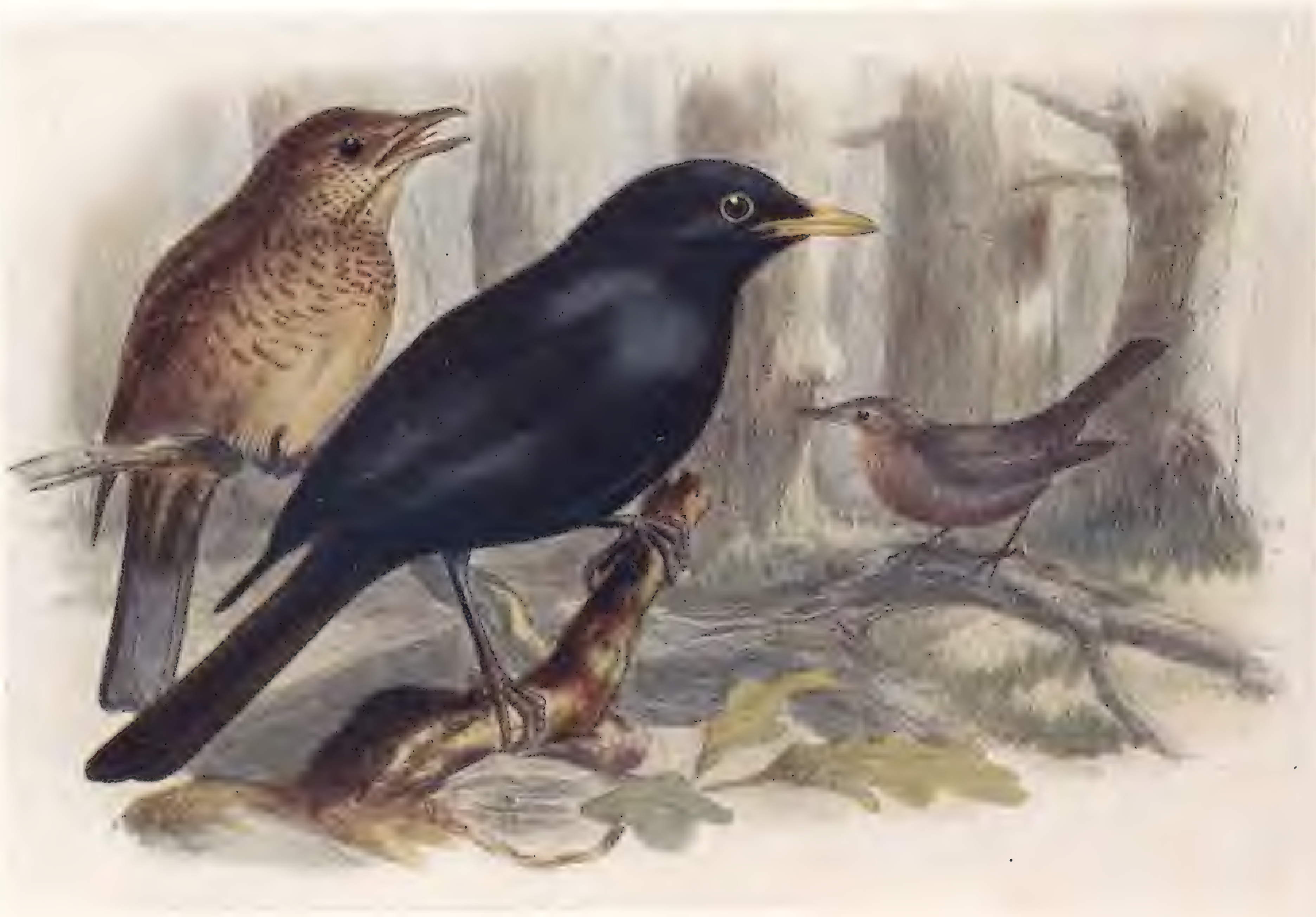
Organically-formed Rocks owe their existence to plants and animals, whose hard tissues, shells, and skeletons, are formed of mineral substances. When such organisms perish their durable parts remain, become fossils, and accumulate in great quantities in seas and lakes. Eventually they form beds of rock, sometimes of great thickness. Most of the limestones are organically-formed, and such are composed of the mineral remains of oysters, whelks, mussels, and numerous other shellfish whose shells, formed from carbonate of lime extracted from water, are their skeletons. Corals have skeletons of carbonate of lime, and the coral reefs which they build become consolidated into limestone. Sea-lilies, known as *Crinoids,* are really animals, and their long stems are composed mainly of carbonate of lime ; they, too, make a contribution to the limestones, and the same may be said of those most interesting creatures of microscopic proportions, known as *Foraminifera*, whose tiny shells of carbonate of lime accumulate in countless millions on the sea-beds. Some plants—seaweeds—also add to the deposits of lime. That a bed of limestone consists of the skeletons of myriads of creatures of past ages compacted till they have become solid rock is a marvellous fact, and one that almost staggers the imagination. Think of the almost infinite time it must have taken for them to accumulate. Some organically-formed limestones are thousands of feet thick. *Chalk* is a variety of limestone, and it is composed chiefly of the microscopic shells of the wonderful foraminifera.

When plants occupying marshy places decay, they produce certain acids which act chemically upon salts of iron contained in stones and rocks under water. The iron is dissolved and removed, but later may be laid down in a new form known as *Limonite*, or bog-iron ore.

Sponges, as you know, are animals ; their skeletons are called *siliceous*. Silica is found in the form of flint. Other tiny animals, called "Radiolarians," have flinty skeletons, and so have the very tiny plants called "Diatoms." All three have played their part in the formation of *Siliceous Deposits*, which are found in the forms of *Flint* or *Chert*.

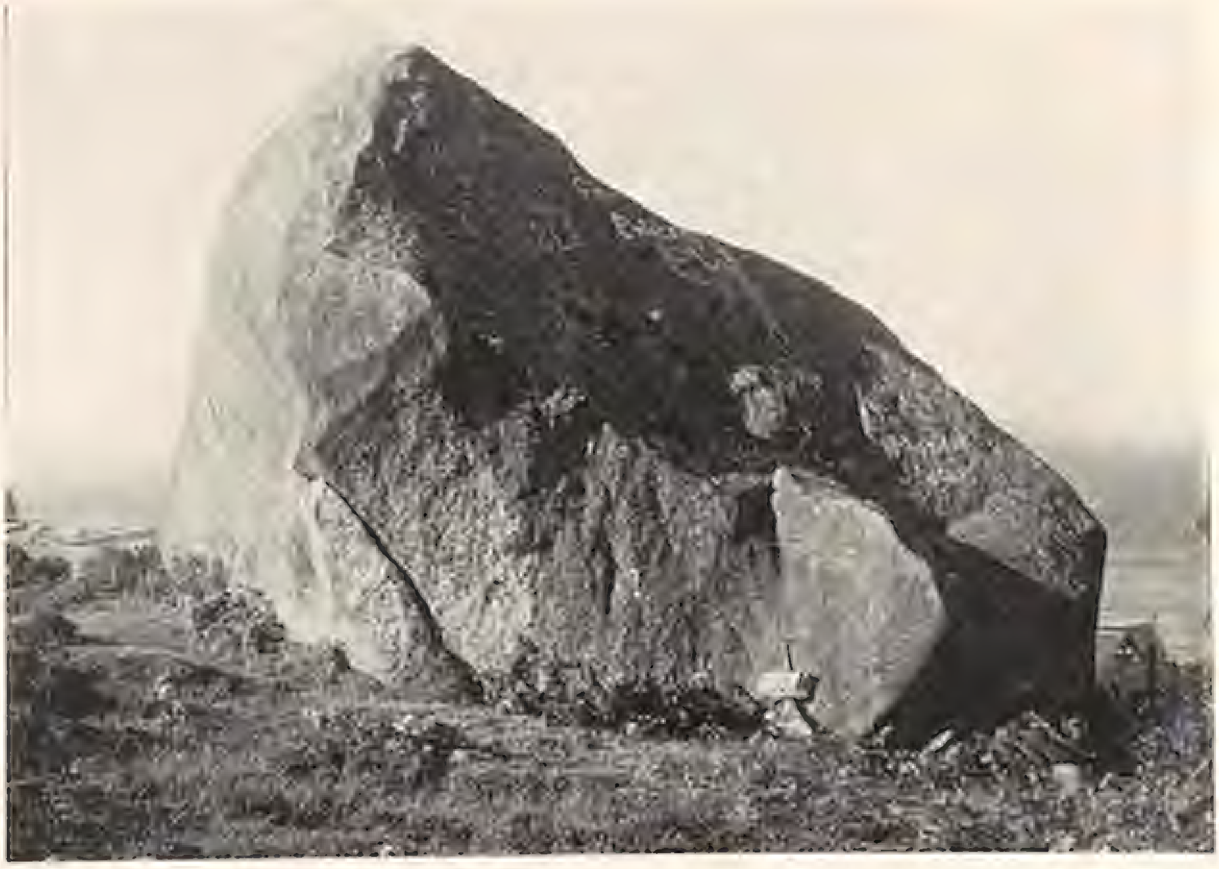
Then those exceedingly important rocks known as *Carbonaceous* are of organic origin. They include *Peat*, *Lignite*, *Ordinary Coal*, and *Anthracite*. What thanks we owe to Nature for such useful substances !

PLATE 10

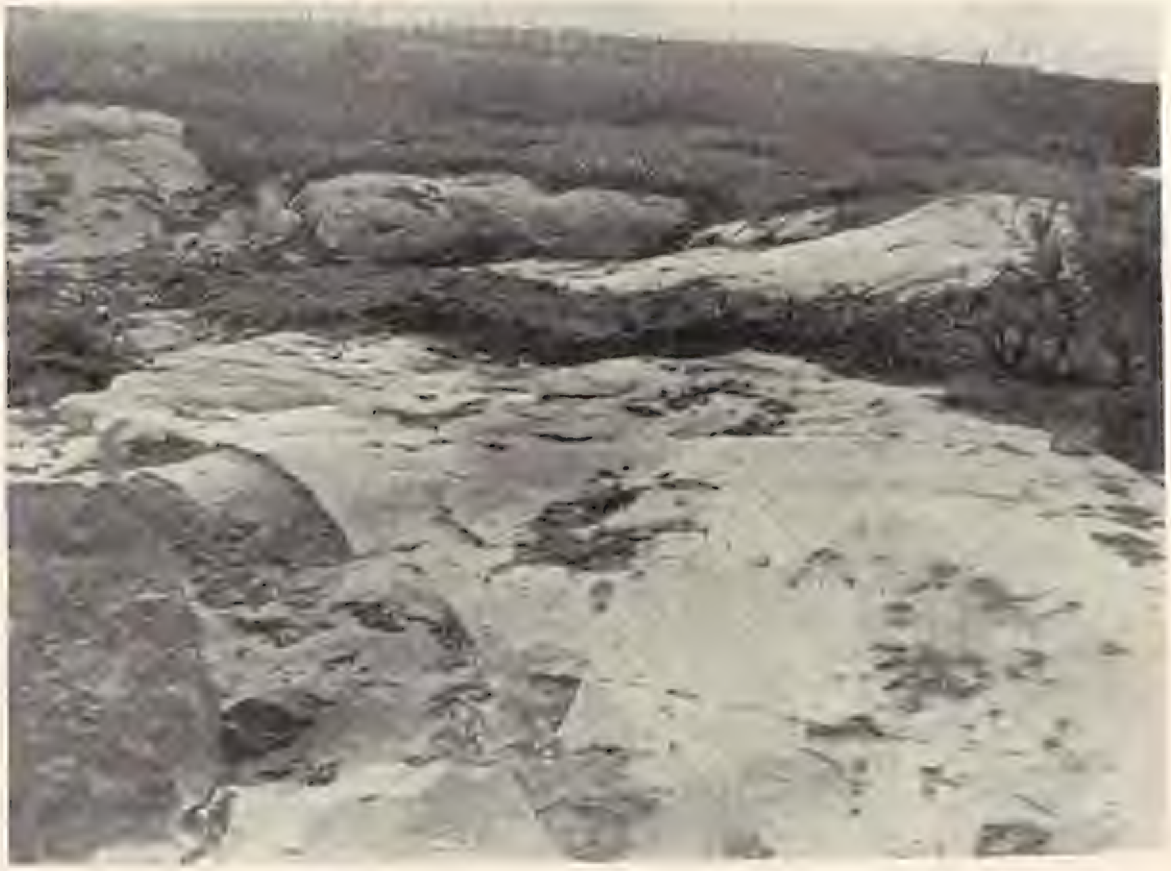


Blackbird. *See page* 155.

Adult Male (*centre*), Adult Female (*right*), Young (*left*).



(*a*) "Clach Mhor"—Huge Ice-carried Boulder, Corrie, Arran. *P.* 37.



(*b*) Sandstone Surface with Ice Markings. *P.* 38.

What could modern civilization do without them? The geologist includes all these substances under the term "rock," as is also the case with clay, marl, sand, and gravel.

Peat is composed of partly decayed mossy plants; it is fibrous in texture, compact, claylike, and quite black in the lower parts of a bed, but at the surface loose, and providing food for living plants which send their roots down into it.

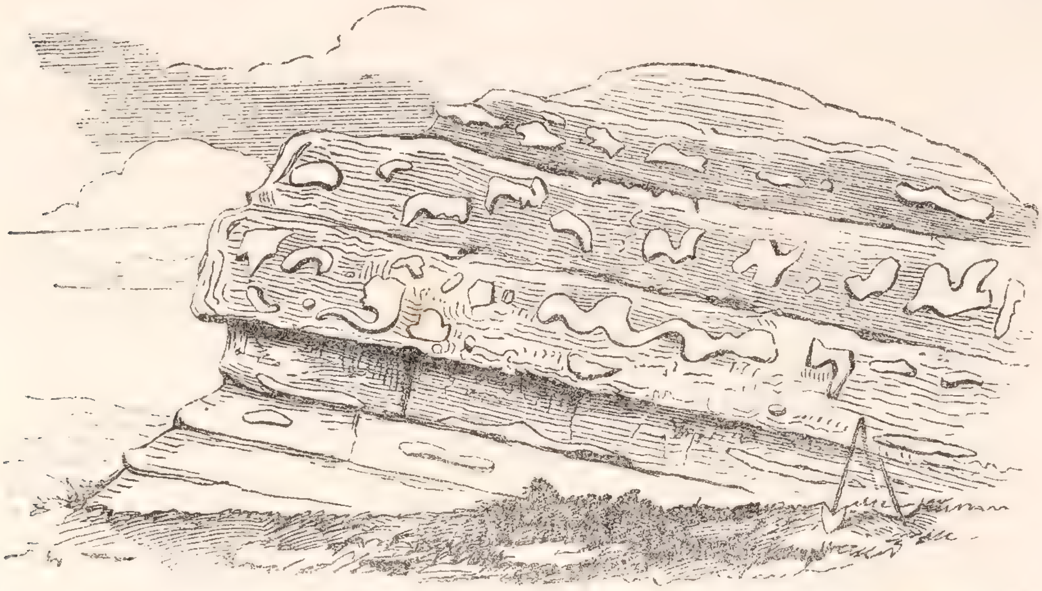


Fig. 3.—Sketch of Limestone Beds containing Nodules of White Chert at Middleton Moor, Derbyshire.

Lignite, also called "Brown Coal," is intermediate between peat and ordinary coal. It is decayed vegetation that has been more chemically changed and subjected to higher pressure than that which forms peat. It may be regarded as fossil wood.

Coal is mineralized vegetation—that is, decayed vegetable matter that has been mixed up with and buried in sediments, and under great pressure, and some chemical action, converted into the valuable mineral that it is.

Anthracite (Greek, *anthrax* = carbon) bears the greatest amount of carbon of all the carbonaceous rocks. It is vegetation even more highly mineralized than coal.

A few words must now be said about the third great group of rocks called METAMORPHIC. This term is derived from the two Greek words, *meta* = change, and *morphe* = form, and the metamorphic rocks are such as have been changed from their original condition by heat, pressure, and great earth movements. Molten rock, which has forced its way through fissures in sandstones to form dykes, changes the character of the sandstone which it touches ; its heat converts sandstone into *quartzite*. Certain sandstones have also been turned into schists. Both igneous and stratified rocks are subject to metamorphism. *Marble* is altered limestone. What is known as *Gneiss* may be an altered granite.

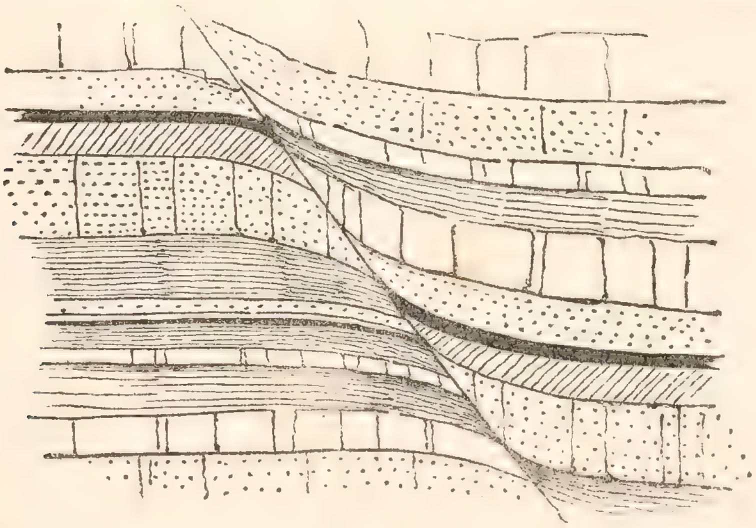


FIG. 4.—DIAGRAM ILLUSTRATING BEDS OF STRATIFIED ROCKS WHICH HAVE BEEN DISTORTED BY A FAULT.

The earth movements which have raised up continents and mountain-chains, and caused land surfaces to sink beneath the waves, have naturally affected the rocks to a considerable extent. Such movements have actually changed the textures of rocks, and been the means of rearrangement of their component minerals. The rounded grains of some sandstones have been flattened into plates, and their appearance has been changed completely. And it is to earth movements that *faults* and *foldings* are due. Stratified rocks, whose beds were originally level, have been tilted at an angle (Fig. 3); their continuity has also been broken; parts of them have sunk, or have been raised along a line of breakage which is known as the "line of fault." On the right side of that line the beds may have remained in their original position, while on the left they may have been lowered to a considerable depth. Or there may have been an upward movement of the strata on one side of the line of fault, and also a downward movement of those on the other, causing the strata to be bent along the plane of fault, as in Fig. 4. There is a line of fault across Scotland, which may be traced for 125 miles; it is the boundary between the Highlands and the Lowlands. On the south side of this fault the rocks are estimated to have sunk several thousand feet. There are many extensive faults, but numerous quite small and local ones occur. An old lady once said that geologists were very ungodly people because they were always looking for faults in the works of God! To be exact, faults are not flaws in Creation, but marvellous agencies which have been the means of revealing many geological truths which would not otherwise have appeared, and they have also secured the preservation of minerals which have enriched mankind. The great Scottish boundary fault is a case in point. It has turned up the edges of strata that would ordinarily have been buried deep below the surface, but which can now be walked over and examined; it has also preserved much coal, iron, and oil shale in the depression it has caused, which might otherwise have been broken up by the weathering agents, and have been washed away.

Earth movements have actually thrust some older rocks over newer ones, and they have caused other rocks to be folded and crumpled. Folding is due to what is called "lateral pressure." If you take a good-sized book, and press its edges between your hands, it will assume a wavy and crumpled appearance. Well, in some instances, as in parts of the Scottish Highlands, rocks have been subjected to such lateral pressure, and in consequence they are now crumpled and folded, as well as altered. I give you a picture of such a rock on Plate 12, *c*, and also in the accompanying illustration, Fig. 5.

The inclination of rocks is called their *dip*, and when earth movements have caused the edges of rocks to appear at the surface, those edges are known as *outcrops*.

When you are rambling over the country with eyes open for interesting things, you are almost sure to find some evidences of the work of glaciers, which at one time in geological history were exceedingly extensive in Northern Europe and North America. During what is known as the Great Ice Age, Northern Europe was literally buried under vast ice-sheets and snowfields. The mountains of Britain were under perpetual snow. From the mountain-snows glaciers were formed, and they found their way down valleys and on to the plains, carrying with them fragments of rock, even boulders of many tons in weight, as well as earth and stones. The under surfaces of the glaciers were rough with stone fragments, which rubbed against the rocks over which they were forced, making grooves and scratches by a grinding action. When the glaciers reached the plains they melted, and dropped the fragments they had carried. These fragments are often found in heaps, and as scattered boulders.

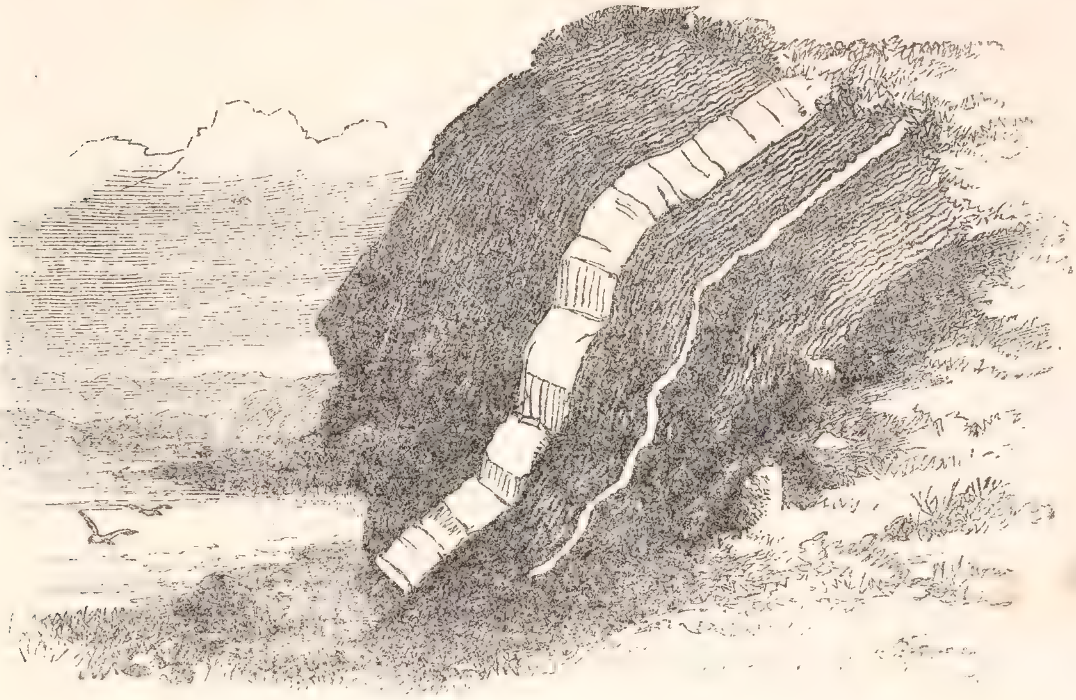


FIG. 5.—FOLIATED ROCKS, LOCH FYNE.

Dark wavy layers are shales metamorphosed into schists, and the white bands are much altered sandstone.

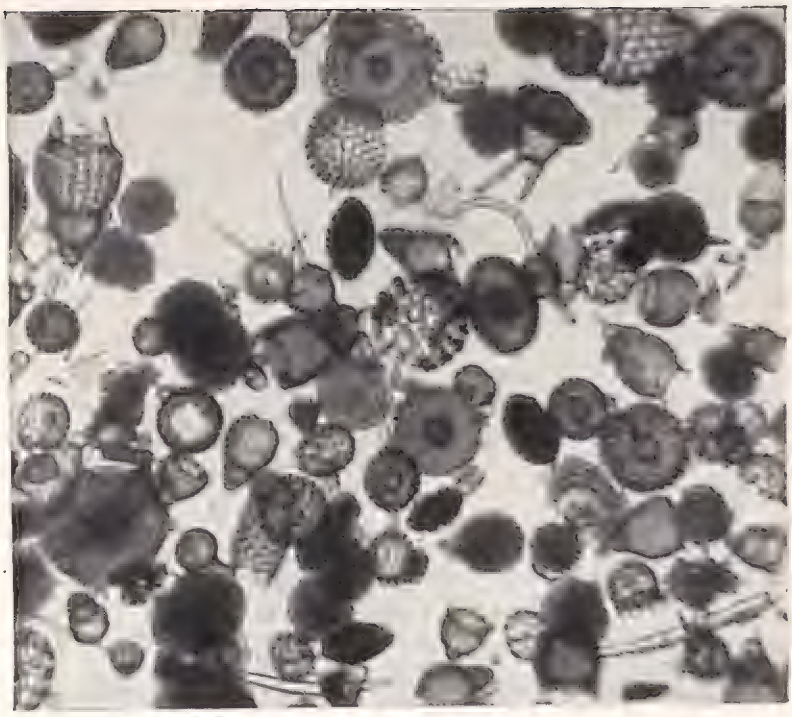
A little thought will make it clear to you that fragments torn away from mountains, carried several miles by glaciers, and dropped in some valley or plain, may very probably be of different material from the rocks of the ground where they are deposited. For example, a glacier, say, passed down a steep slope formed of granite, and picked up some fragments of granite on its way. These fragments became attached to the under surface of the ice, and in their passage over the underlying rock scratched it, and became scratched themselves. The glacier farther down the slope passed over a different kind of rock, say, a slate; the slate was also scratched by the fragments of rock, and some loose pieces of slate were picked up by the glacier. These fragments of slate also scratched the underlying rocks, and became scratched themselves. By-and-by the glacier descended to a plain whose rocks were sandstone; there it melted, and dropped the pieces of granite and slate it had dragged along with it. Now, to-day you and I ramble over that sandstone plain, and find some ice-marked and scratched boulders of granite and slate. We want to know what they are doing out of their proper place; they are foreigners, miles away from their homes. Geologists call them *erratics*. Having found these erratic fellows, we should like to trace them to their homes. We ramble about with eyes very wide open; we ascend the slope on to the region of slate; and, behold! on some exposed surfaces of the rock there are grooves and scratches—*striations*, say the learned scientists. We examine these striations carefully; they all point in the same direction! A few hundred yards farther up the slope there are more exposed surfaces and more scratchings, still pointing the same way. Still higher we toil, until we reach the granite. What can we say but that we have found the rocks where the granite and slate boulders came from, and that they must have been carried to the plain by a glacier ? Have we not traced the direction of the ice-flow as indicated by the scratchings, and when we compare the boulders with the mother-rocks are they not similar in texture and composition ?

Why, boys and girls, you say Sherlock Holmes was a wonderful detective, and when you read about his doings, which are pure fiction, you think you would like to do some detective work on your own accounts. Surely you can be detectives in the very best sense of the word. Have I not just shown you how to solve a problem of Nature ? If you devote yourselves to Nature-study you will find some almost brain-cracking problems to solve, and you will be able to turn your intelligence to better account than in solving criminal mysteries, fictitious or real. You will find some rock fragments that have been carried by glaciers which have not been scratched, ground, or rounded. Such fragments have been carried on the top of the ice-sheet, and have not been subjected to rough usage. They have, of course, dropped to the ground when the ice melted. A glacier, it should be noted, does not travel as a solid block of ice, but more after the manner of slightly melted pitch, yet much slower. Glaciers are also credited with laying down the *Boulder-clay*—a clay which is full of boulders of various kinds of stone.

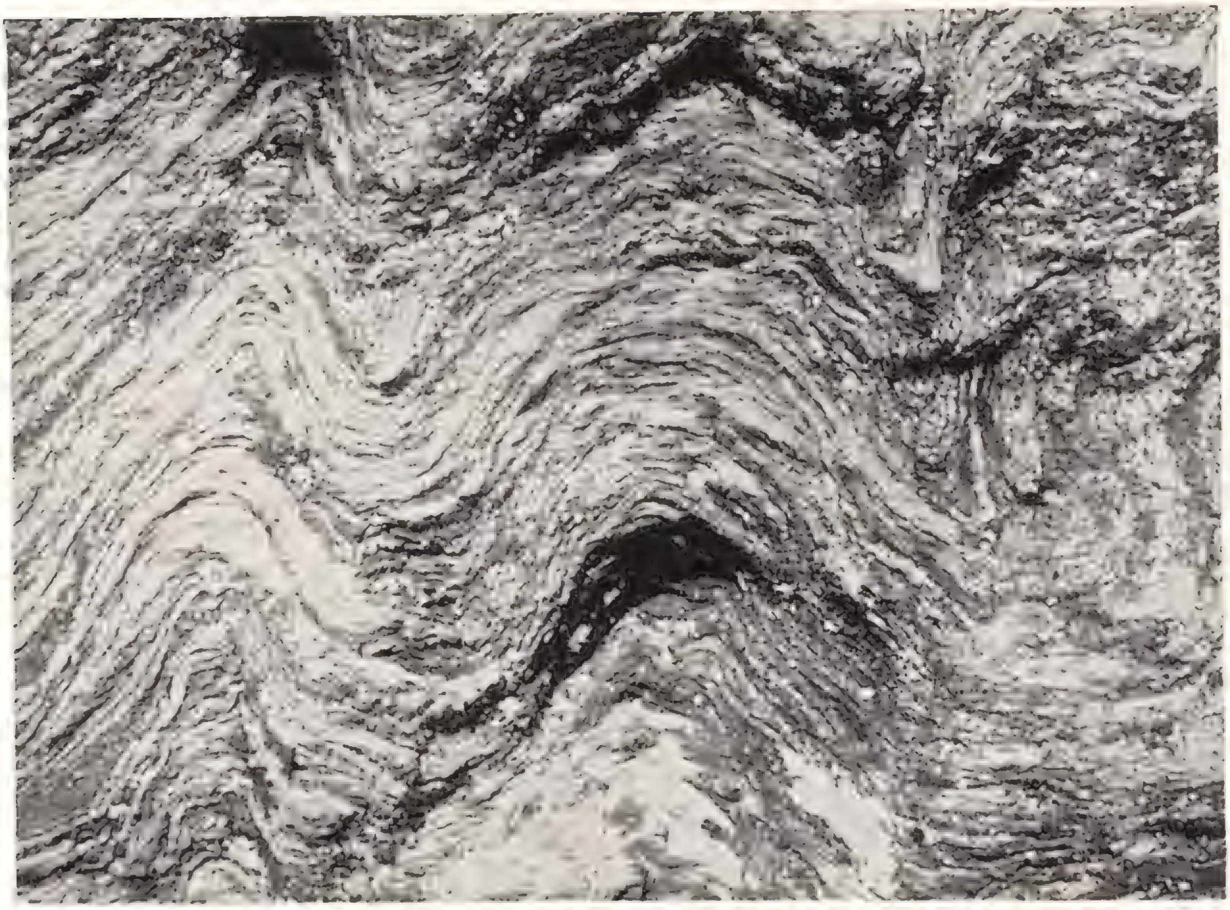
This chapter has grown longer than I intended it to be ; yet how little I have told, and how much there is to tell ! I have written little or nothing about fossils, which in truth demand a volume to themselves. Young people, however, are interested in fossils even more than in minerals and rocks, and the next chapter must contain a short account of some fossils that are commonly found. Besides, the study of fossils is most important, for these relics of past ages are very useful in helping us to decide the age of the rocks in which they are found.

But in regard to the rocks, you must do some practical work. Let it be your aim to understand, as well as you can, the geology of your own district. Cover the ground two or three miles from your homes in all directions. Ascertain the nature of the rocks and deposits in the area, look for faults, erratic boulders, and evidences of ice-action. Observe the character of the soil, the dip of strata, and satisfy yourselves about past volcanic action. When you have accumulated some knowledge of your local geology, prepare a map showing the various rocks in different colours, and indicate as correctly as you can the positions they occupy. Also prepare a diagram of a section cut clean through the strata in any direction you may think best ; in this way you can show the rocks that are below the surface, and demonstrate the order of strata. These sectional diagrams are not easy to make, but you should do your best with them, always being willing to ask for information and assistance from friends who have more experience. A geological hammer will be useful to you on your rambles. Such a hammer as is pictured in Fig. 6 can be purchased for about a couple of shillings ; you will see it has breaking and cutting edges. With the flat end of the head you

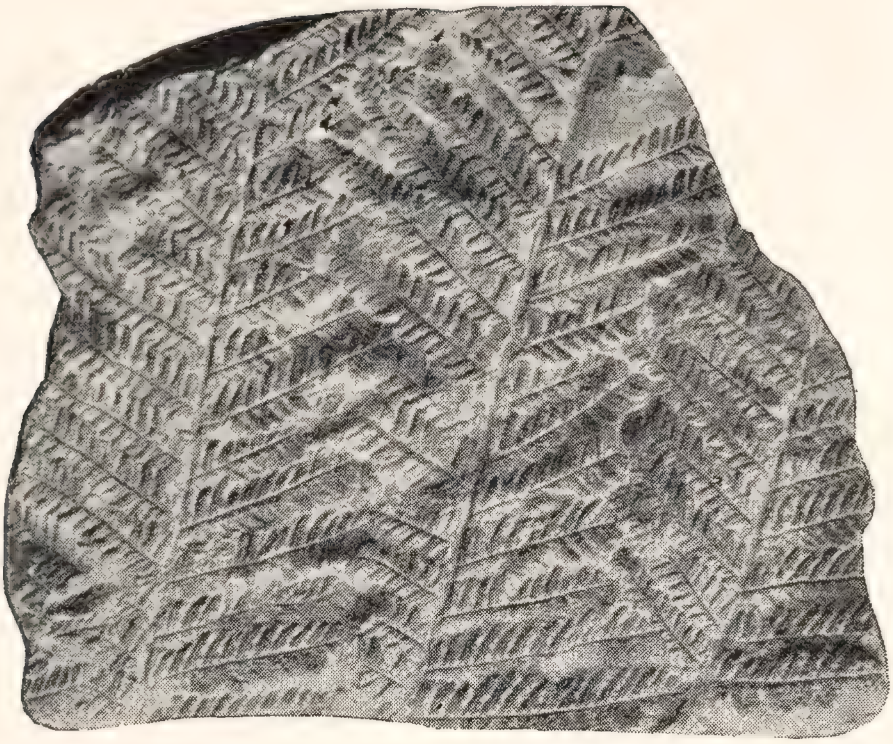
(*a*) J. F. Jackson. *P.* 44.



(*b*) Radiolaria (magnified). *P.* 55.

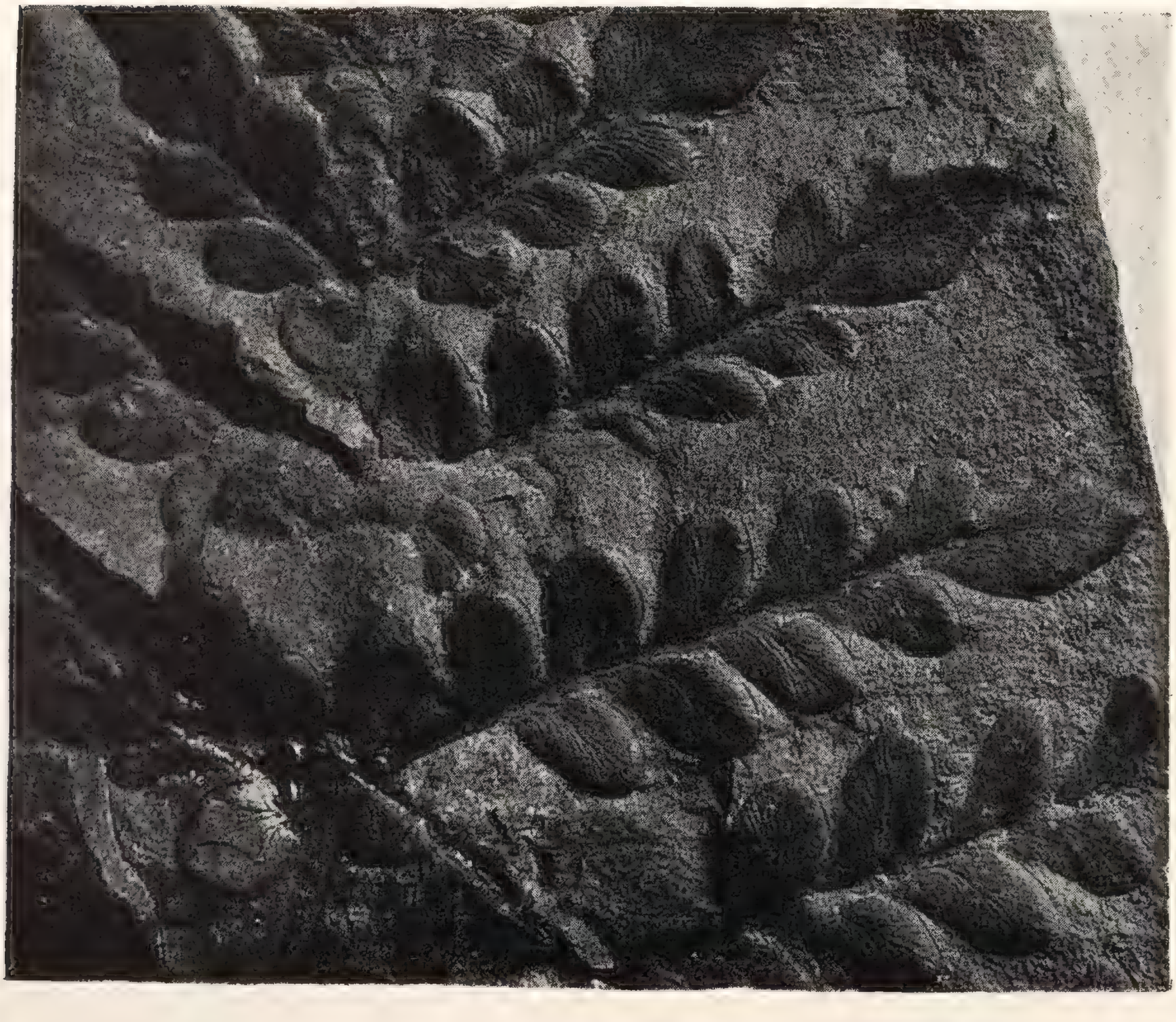


(*c*) Folded Schists. *P.* 36.



(*a*) Fossil Fern Frond (*Pecopteris dentata*).

From D. H. Scott's "Fossil Botany," by permission of the Author.



(*b*) Part of Frond of *Neuropteris heterophylla*, in Fossil State.

From D. H. Scott's "Fossil Botany," by permission of the Author.

can break rocks and get a clean fracture; with the sharp end you can chip, cut, and split.

Then, again, you should form a collection of specimens illustrating your local geology. If you have igneous rocks near you, secure nice cleanly fractured pieces of them, pieces that will show their texture and component minerals. Put each specimen in a suitable cardboard tray, which you can easily make, and attach a label giving name of the specimen and locality in which it was found. The specimen trays can be placed neatly side by side and end to end in a shallow box, which will serve better if it has a glass lid. Collect specimens of minerals, such as quartz, calcite, iron pyrites, and arrange them in trays in a similar way. Do the same with the stratified rocks, and even with such surface deposits as sand, clay, and soil. Let everything that exists in your geological area be represented in your geological museum. You will, of course, arrange your specimens in their proper order, and be exceedingly careful in the naming of them. Aim at accuracy in every detail of your work; don't

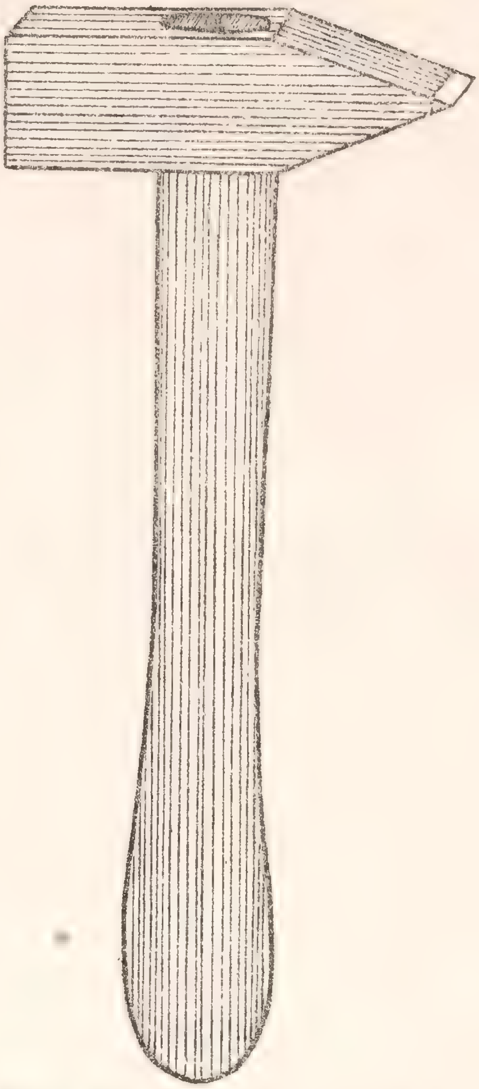


FIG. 6.—A GEOLOGIST'S HAMMER.

give an opinion about any rock or mineral, much less give it a name, until you are confident you are correct in your observations and conclusions.

I have heard grown-up persons, who ought to know better, say, "There is no geology in my district," or, perhaps, "The geology in my neighbourhood is very meagre." Let me say that there is no district where the study of geology cannot be practically pursued. Some districts are undoubtedly richer than others in geological wonders and prob-

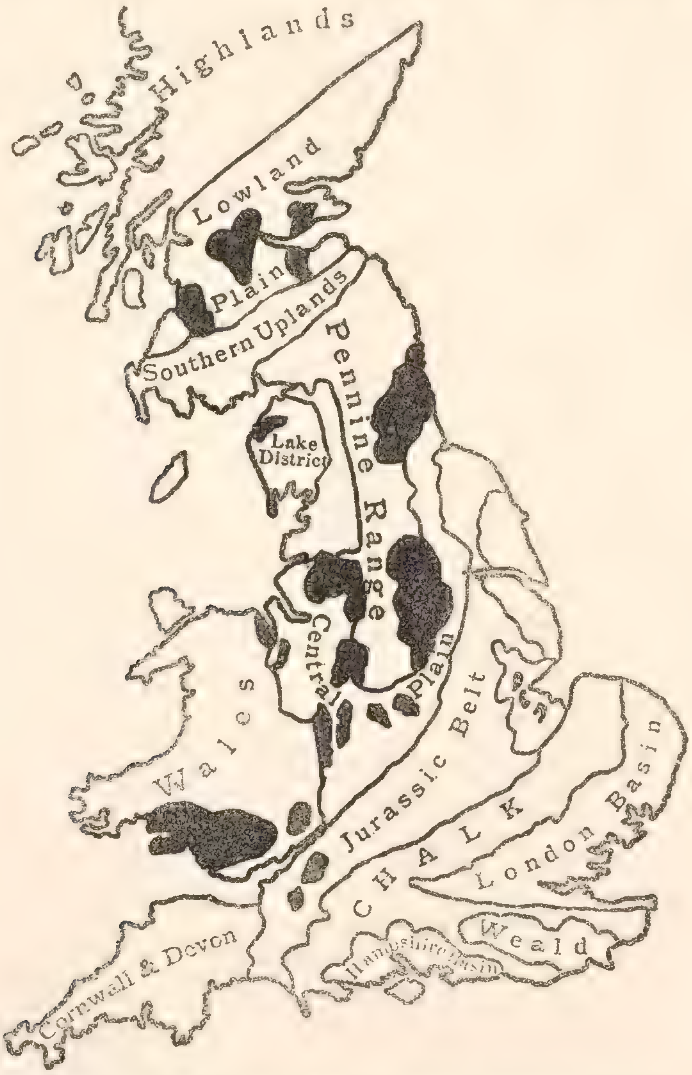


FIG. 7.—COAL-FIELDS AND NATURAL DIVISIONS OF GREAT BRITAIN.

lems, but there is interesting and valuable work to be done where no hills or crags appear, and the ground for miles is as level as a billiard-table. You can ascertain why the ground is so level, determine the origin of the soil, find out from borings and cuttings what rocks lie below the soil. Moreover, you can hunt for fossils, and determine the relation of the deposits of your district to those of other districts which show different features. In fact, there is unlimited work to be done everywhere.

What interesting companions you will be when you can tell your chums and grown-up friends all about the geology of your district, and what pleasure you will have on your walks at home and abroad when you can take an intelligent interest in the rocks and the ground over which you walk ! Make Nature yield some of her buried secrets. Maybe you will some day enrich the world with the fruits of a great discovery.

BOOKS TO READ.

Geology. Professor Gregory. Dent's Scientific Primers. 1s.

Class-Book of Geology. Sir Archibald Geikie. Macmillans. 5s.

Geology for Beginners. W. W. Watts. Macmillans. 2s. 6d.

The Story of Lost England. Beckles Willson. Newnes. 1s.

Outlines of Field Geology. Geikie. Macmillans. 3s. 6d.

CHAPTER III

SOMETHING ABOUT FOSSILS

I HAVE before me a newspaper cutting which tells of some good work done by a fifteen-year-old Hunstanton boy. It says this boy, named Jackson, who is in very humble circumstances, and has had little schooling, has published a book entitled: "The Rocks of Hunstanton and its Neighbourhood." The book describes the various forces which have been active in the formation of geological strata, with special reference to the Hunstanton district, and it gives an account of Hunstanton Cliff, glacial deposits, the submerged forest, and the red chalk found there. When Jackson was only ten years old he had a book on geology given to him by a visitor. He became greatly interested in the subject, studied his local geology, gathered a fine collection of fossils, and now has written a book. You will find a portrait of Jackson on Plate 12, *a*.

Well, I hope my present effort will induce many young people to do what Jackson has done. If he could get such an amount of geological knowledge by the time he was fifteen as to enable him to write a useful book, surely others with thought and application can do something as useful. At any rate, he has set an example which is worthy of serious consideration.

This chapter is to be devoted to fossils. I want to tell you what fossils are, say something about the rocks in which they are found, give you some idea of the story they tell, describe and picture some of them, and give you a few hints about collecting.

A fossil, literally, is something dug up, and the term applies to remains or impressions of animals and plants which are found in rocks, or naturally placed amongst clay, sand, or gravel. A fossil may be a petrified plant or animal, or an impression of such. A petrified tree-trunk is a fossil, and so is the impression in limestone or shale of a shell or a fern. The rocks have preserved burrows of worms, and even the footprints of birds, and these are also called fossils.

The fossils we find in the rocks to-day are only a slight indication of the number and variety of living creatures which occupied the world in past ages. The bodies of many creatures are too perishable to become fossilized, except under very particular circumstances. Creatures of the sea are more likely to be preserved in fossil form than land animals and plants, and for this reason the majority of fossils found are of the marine type.

From fossils we can learn much about the story of Creation, and of the living inhabitants of the world from very remote times. Fossils also give us clues to the geography of the age in which the creatures they represent lived, and show us how there have been changes in geography. You know that chalk was formed under water ; if, therefore, you find chalk with its characteristic fossils in a high and dry land surface, you know it was at one time a sea-bed. If you find remains of trees firmly rooted in a sea-bed, you know that it was once a land surface. The reindeer flourishes in a cold climate, and it is fair to presume that a cold climate once obtained in regions where its fossil remains are found. If you discover deposits containing bones of elephants and lions, and leaves of tree-ferns or palms, you conclude that the climate was tropical when the deposits were formed. Fossils, moreover, help you to understand the great procession of life, how certain creatures lived and flourished in certain periods, and by-and-by became extinct, to be followed by other creatures superior to them in many ways. Certain fossils are associated with particular formations, and we are able to know a formation by the fossils it contains.

The stratified rocks have been deposited through an incalculable period of time. The oldest of them are so old that it were foolish to even guess their age in years. But we know something of the order in which they were laid down, and the fossil contents of rocks enable us to decide which rocks are very old, which are less old, and which are of comparatively recent date. I am now going to give you the order of the stratified rocks from the earliest to the most recent. Geological time is divided in Eras, which are four in number :

1. Eozoic (Greek, *eos* = dawn, *zoe* = life).
2. Palæozoic (Greek, *palaios* = ancient, and *zoe*).
3. Mesozoic (Greek, *mesos* = middle, and *zoe*).
4. Cainozoic (Greek, *kainos* = recent, and *zoe*).

The derivations of these names give you a clue to the Eras they represent. Eozoic rocks contain fossils of some of the earliest forms of life, while Cainozoic deposits include remains of recent forms of life.

For purposes of classification and study, the Eras are divided into Periods, which I shall now set down in tabular form, giving you typical fossils of each Period, and some other details.

THE EOZOIC ERA.

Period.	Estimated Thickness of Strata in Feet.	Nature of Strata.	Where Strata are Represented.
Archæan (Greek *archaios* = ancient)	50,000	Metamorphosed Igneous Rocks, Schists, Quartzites, Crystalline Limestones, Conglomerates, Sandstones, Shales	Shropshire, Warwickshire, Worcestershire, Leicestershire, North-West Highlands of Scotland, Finland, Scandinavia, Canada, etc.

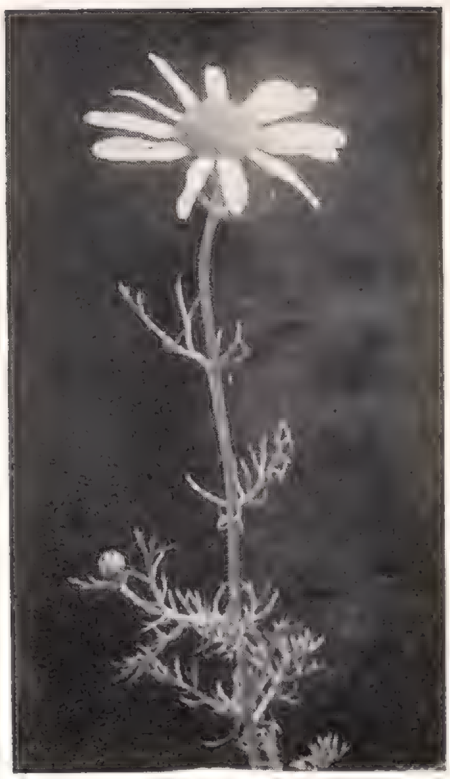
The lower Archæan rocks contain no fossils ; they consist largely of metamorphosed igneous and sedimentary rocks, but the absence of fossils must not be taken as evidence of there being no living creatures at the remote age they represent. Creatures of lower Archæan date may have been very low in the scale of life, and have had no skeleton to endure, or if they had skeletons, the deposits in which they were laid have been subjected to so much compression and change that the remains have got beyond recognition. In the upper Archæan rocks there are traces of life. Seams of limestone therein may have been organically formed, and some graphite has been found, which may be greatly altered seaweeds. The Torridon Sandstone of the North-West Highlands of Scotland has yielded some grains of phosphate, which seem to be organic in nature.

Let us proceed with our table (see p. 49).

THE PALÆOZOIC ERA.

It will be interesting for you to have some reasons for the names given to the Periods of the Palæozoic Era. The name " Cambrian " comes from *Cambria*, the old name given to Wales, where the Cambrian rocks are typically developed. " Ordovician " rocks appear typically in the country once occupied by the tribe called *Ordovices*, in Shropshire and East Wales. The *Silures*, who in Roman times held part of Shropshire, also Central and South Wales, have the " Silurian " rocks named after them. The term " Devonian " comes from *Devonshire*, where these rocks were first studied. " Carboniferous " comes from *carbo* = coal, and the name is given on account of the Coal Measures which are conspicuous in the rocks of the Period. " Permian " relates to the province of *Perm*, in Russia, where the rocks are typical.

The fossils of the Palæozoic Era are largely the remains of families, orders, genera, and species of creatures that are now extinct. The Trilobites, of which I shall have more to say, existed from Cambrian to Permian times, when they seem to have



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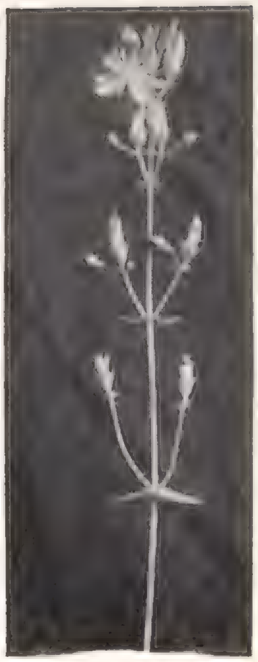

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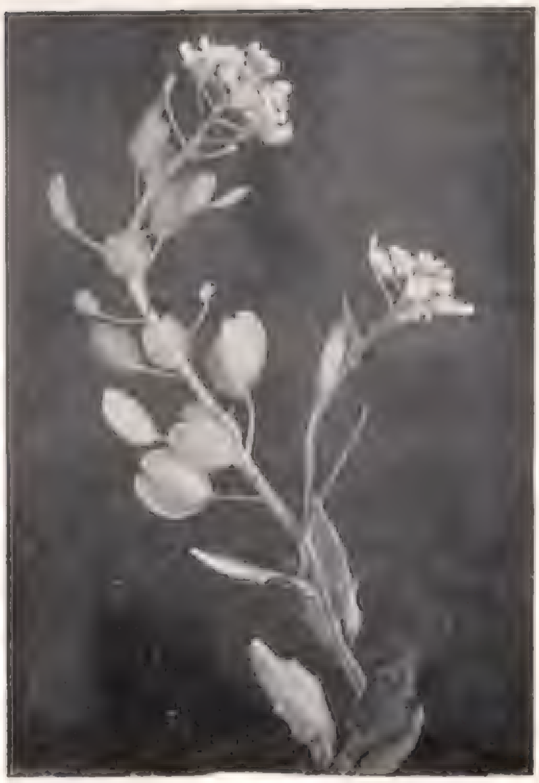

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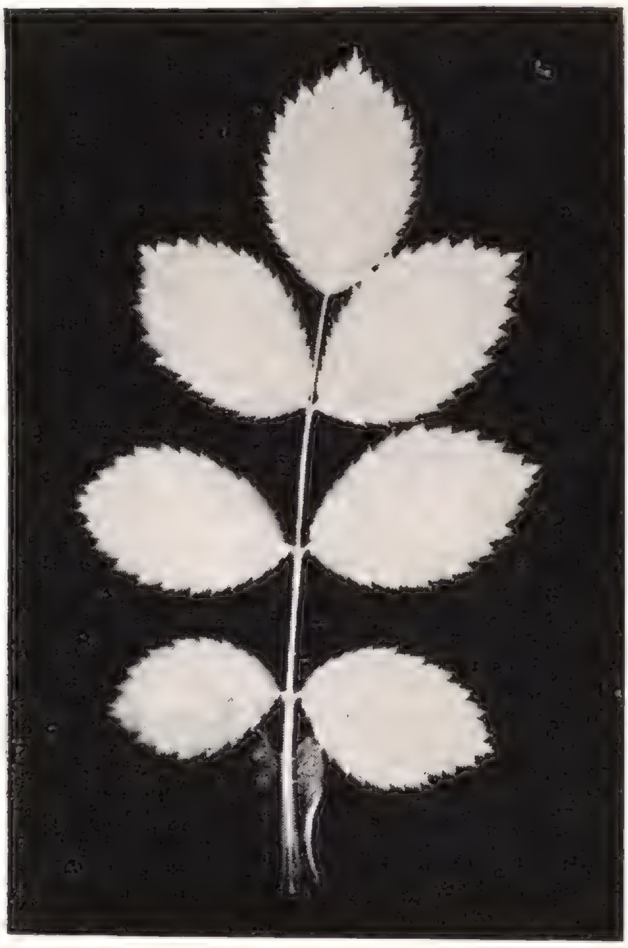

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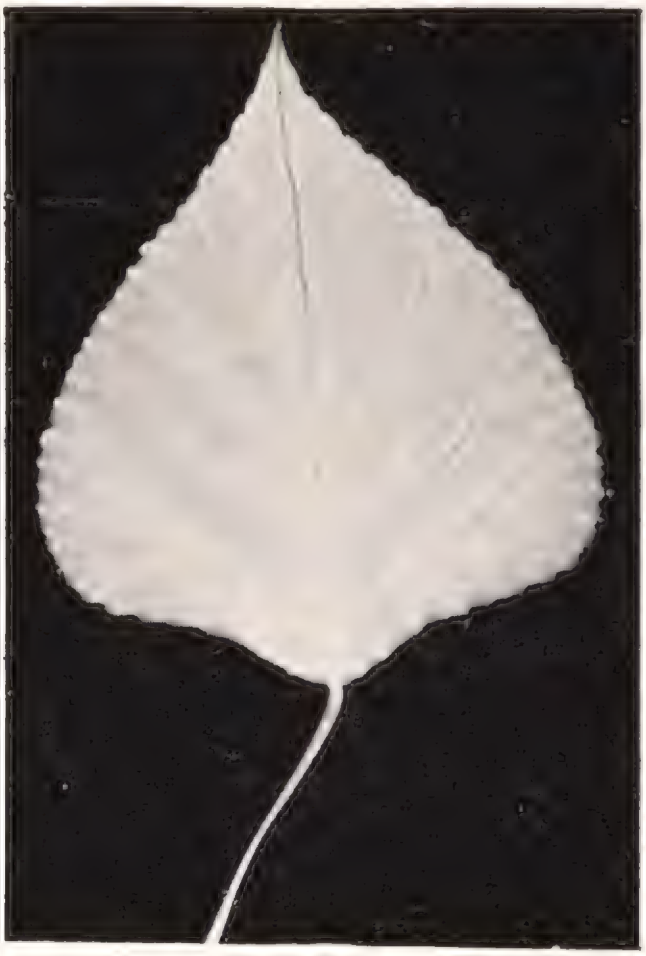


(*e*)

(*a*) Scentless Mayweed. *P.* 233.

(*b*) Upright St. John's Wort. *P.* 130.

(*c*) Field Penny Cress. *P.* 132.

(*d*) Nature Print of Leaf of Dog-Rose. *P.* 134.

(*e*) Nature Print of Leaf of Black Poplar. *P.* 134.

PLATE 15

(*a*) Horsetail Plant. *P.* 98.

(*b*) Foxglove.

(*c*) Potato-Tubers. *P.* 120.

(*d*) Angelica.

THE PALÆOZOIC ERA.

Period.	Estimated Thickness of Strata in Feet.	Nature of Strata.	Where Found.	Typical Fossils.
Cambrian ..	12,000	Sandstones, Flagstones, Slates	Wales, England, North-West Scotland, East of Ireland, elsewhere in Europe, Asia, South and North America	Trilobites
Ordovician ..	15,000	Grits, Quartzites, Flagstones, Shales, Slates, Sandstones	Shropshire, Wales, Lake District, etc.	Graptolites
Silurian ..	7,000	Shales, Slates, Limestones, Mudstones, Conglomerates, Sandstones	Shropshire, Wales, Lake District, South Scotland, Scandinavia, Russia, Spain, North America, etc.	Earliest Fishes, Marine Scorpions
Devonian ..	5,000	Grits, Sandstones, Slates, Limestone	Devonshire and Cornwall, Scotland, Wales, the Continent, North America, etc.	Armoured Fishes
Carboniferous	12,000	Sandstones, Fire-clays, Ironstones, Coals, Grits, Shales, and Limestones	Wales, Lancashire, Derbyshire, Yorkshire, Northumberland, Central Scotland, parts of Europe, Australia, New Zealand, North Africa, China, North America	Scorpions, Fishes, Labyrinthodonts, Giant Horsetails, Tree-ferns, Club-mosses
Permian ..	1,500	Red Sandstone and Marl, Magnesian Limestone, Marl, Slate, Lower Red Sandstone, Breccias	Perm (in Russia), Southern Africa, Southern India, New South Wales, Germany, France, North America, England, Scotland, etc.	First Reptiles, Cephalopods

become extinct. In Palæozoic times there were kinds of fish, sea-lilies, starfish, sea-urchins, and corals, which did not live beyond the Era. There are no traces of birds or mammals in these early formations. The Graptolites became extinct at an early Period.

THE MESOZOIC ERA.

The name "Triassic" was given to the rocks it represents on account of their threefold development in Germany. The *Jura* Mountains, where "Jurassic" rocks are well in evidence, give their name to the strata of this Period. The term "Cretaceous" (Latin, *creta* = chalk) is given to the rocks of the Period in which chalk is very conspicuous. The Mesozoic Era was the age of Great Reptiles, some of which I shall describe. But, of course, a great many forms of life existed in addition to the Reptiles. Some new forms of sea-lilies, fishes, and sea-urchins, as well as ammonites, appeared in those times, and some birds were in existence.

THE CAINOZOIC ERA.

I do not think I will tabulate the strata of this Era. As their name implies, they enclose fossils of recent, although not always existing, forms of life. The Palæozoic rocks are sometimes called "Primary," the Mesozoic "Secondary," and the Cainozoic "Tertiary," the more recent rocks of the Era being often named "Quaternary." The Periods of the Cainozoic Era are the *Eocene* (*eos* = dawn,

THE MESOZOIC ERA.

Period.	Estimated Thickness of Strata in Feet.	Nature of Strata.	Where Found.	Typical Fossils.
Triassic ..	3,000	Mottled Sandstones, Pebble Beds, Waterstones, New Red Marls, Shales, and Limestones	Cheshire, Worcestershire, Scotland, Germany, the Alps, India, South Africa, North America, etc.	Theromorphs, Pariasaurus
Jurassic ..	5,000	Beds of Clay, Limestone, and Sand. The Deposits include the Oolites and the Lias	Dorset, Somerset, Oxfordshire, and many parts of England. Poorly represented in Scotland, Germany, Normandy, Provence, etc.	Great Reptiles
Cretaceous ..	2,500	Notably Chalk, various Sands, Clays, and soft Limestone	Conspicuous in South and East of England, and many parts of Europe, North Africa, North America	Cretaceous Fossils closely related to those of the Jurassic. Remains of some great *Deinosaurs* are found in Wealden deposits

kainos = recent), in which existing species of shells began to appear; the *Oligocene* (*oligos* = few, and *kainos*), when there were few recent shells; the *Miocene* (*meion* = less), when there were really more recent forms, but they totalled less than the older species; the *Pliocene* (*plios* = more), when shells of existing species came to be more in proportion to the old shells; and the *Pleistocene* (*pleistos* = most), the shells of this Period being all represented by still living species. The Cainozoic Era is known as the "Age of Mammals," for horses, elephants, mammoths, and a host of other mammals came into being in Cainozoic times, and their fossil remains are found in the rocks of the Era.

I have just finished presenting you with a mass of dry details, which may not prove so fascinating as a fairy-tale, but they are details which the would-be geologist must bear in mind. For fear of overburdening you I have omitted to set down a good deal of information; indeed, I have given you a very bare outline. For the fullest particulars you must refer to books devoted entirely to the science. What I want to make you understand is, that you must study your fossils in a systematic and scientific way. It is not sufficient for you to collect a few fossils and give them names; you must be able to tell the Eras and Periods to which they belong; and the time will come, I trust, when you will have such a thorough grasp of your subject that you will be able to form clear mental images of the living creatures or plants represented by fossils, and also of the circumstances in which they flourished.

From the tabulated figures you will see that the stratified rocks are estimated to be of a tremendous thickness, and you might naturally conclude that the older rocks must be very deep beneath the earth's surface. Many of them are hidden away at great depths, but thanks to earth movements spoken of in the last chapter, the strata in many places have been tilted upwards, and even set on edge, so that we can walk over and examine outcrops of rocks, which, if it were not for ages of earth movements, would be overlaid by many thousands of feet of other deposits.

And now for the Fossils.

I shall tell you first about fossil animals, and afterwards call your attention to fossil plants, and I shall begin with the lowest members of the Animal Kingdom—namely, those which belong to the first of the eight great subdivisions of the animal world. These are called PROTOZOA (Greek, *protos* = first, *zoon* = animal). The simplest members of this division are very minute, jelly-like masses, without legs, arms, eyes, stomach, or any organs, yet they can move, swim, feed, and feel; they can also multiply themselves by division of their own substance. As they have not any skeletons or hard parts, we have no fossil remains of these lowly creatures. There are, however, very lowly, jelly-like creatures which clothe themselves with a covering of carbonate of lime, which they extract from the water in which they live. They are very small, and you need a microscope to examine them with. Their coverings are often like little globes, or several little globes joined together, and they are pierced with little pores, or holes, through which the tiny animals thrust portions of their jelly-like bodies in long thread-like rays. These rays are called *pseudopodia*—*i.e.*, false feet. There are many species of these *Foraminifera*, for so they are called, the term coming from two Latin words meaning "hole-bearing." The rocks bear abundant fossil remains of these creatures; you can trace them from the Ordovician Period up to the most recent deposits. We may boast of our long occupancy of the world, but the life of the human race is hardly worth mentioning in comparison with the long history of the foraminifera. The race of these tiny animals has survived all sorts of changes, and has endured when more powerful creatures became extinct. The majority of the houses in Paris are built of a limestone which is nearly all fossil foraminifera, and the same can be said of the stones used in building the Pyramids of Egypt. Think of the countless number of the skeletons of these animals—skeletons not much bigger, and often not so big as a pin's head—which must be contained in a small block of such rock.

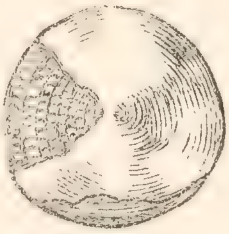


FIG. 8.—NUMMULITES LÆVIGATUS (MAGNIFIED).
Fossil foraminifer from Eocene rocks. The stone of which the Great Pyramid is built is composed mainly of fossil nummulites.

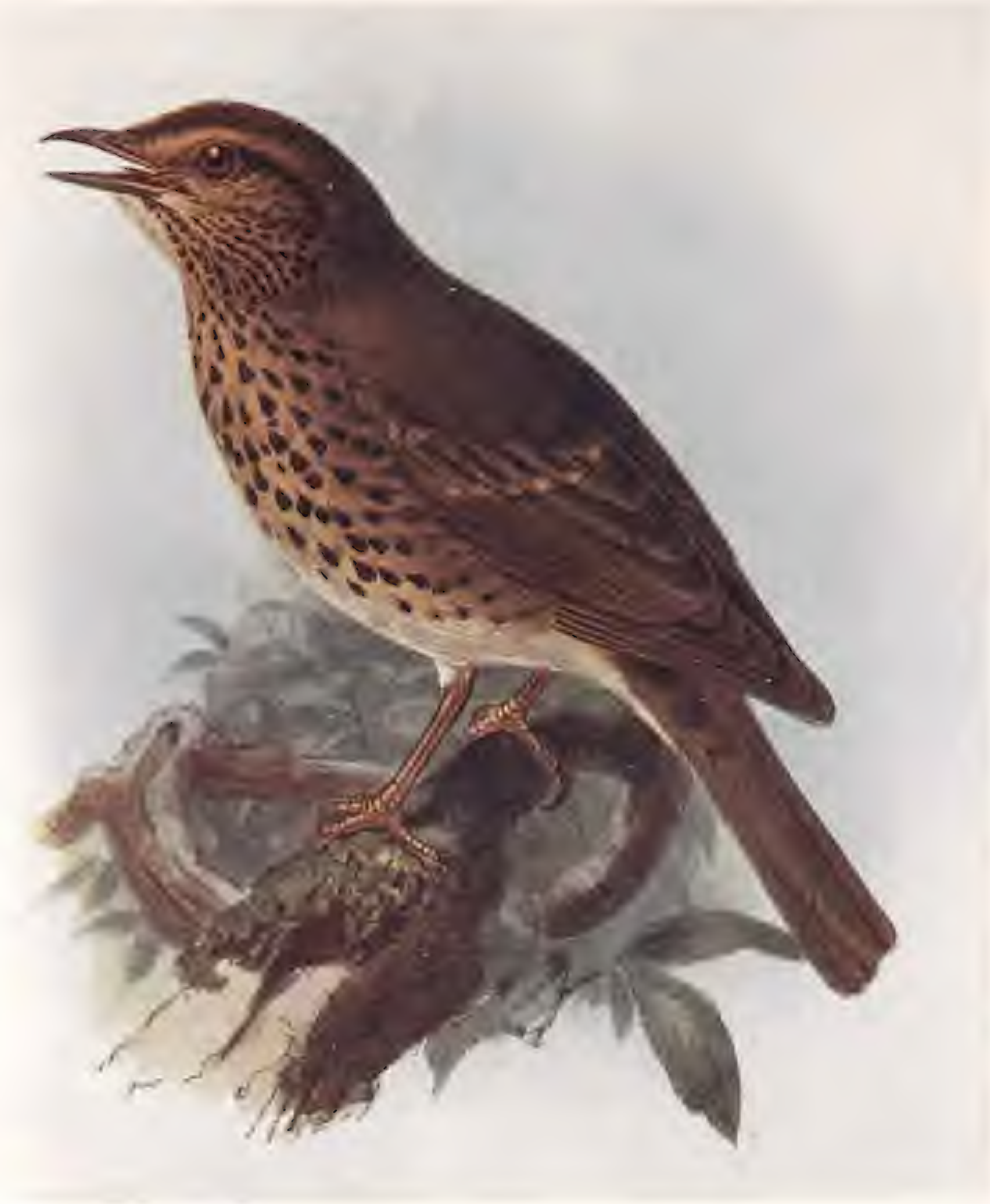
Secure a piece of chalk just as it is gathered from its native place, and gently crush it to powder. Tie the powder up in calico, just as if you were going to make a pudding of it. Get a basin of water, put the bag containing the powdered chalk into it, and knead your mock pudding with your fingers. A lot of the material will find its way through the calico into the water. Go on kneading until about a third of the powdered chalk is left. You will now have a milky fluid in your basin, which will contain a lot of foraminifera. Let the fluid settle, when, of course, it will clear, and the white stuff from the chalk will fall to the bottom. Take this white stuff, put it into a bottle with water, shake well, and pour off the water. Do this several times so that the foraminifera may be well washed. Then if you have no microscope of your own, take your material to a friend who has one, and ask him to let you see some of it through his instrument. You will be delighted with the wonderful forms you can see.

The *Radiolaria* (Latin, *radius* = a ray) are no less wonderful than the foraminifera. Their skeletons are made of flint (silica), and they assume many very wonderful forms. The bodies of these creatures are also projected through holes in their covering. Fossil radiolaria are found in rocks dating from Ordovician times to those of the most recent period; these creatures have had no break in their history, and, of course, living specimens are still to be found. See Plate 12, *b*, for a photo-micrograph of some radiolarian skeletons.

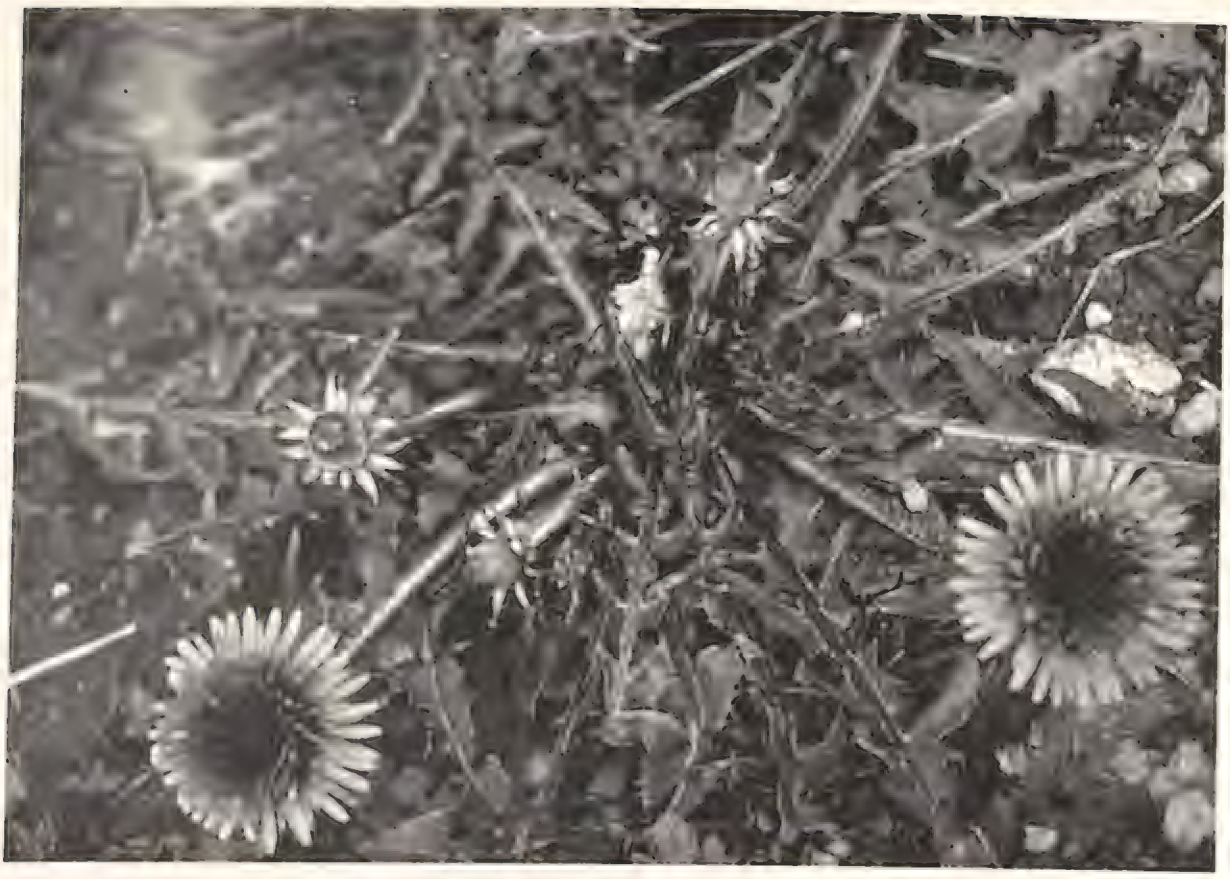
The second great subdivision of the Animal Kingdom, the PORIFERA (pore-bearers), embraces the *Sponges*, which are found in a fossil state in all the geological Periods from the Cambrian upwards. Sponges are more highly organized than foraminifera and radiolaria. Their bodies contain a number of tubes through which water finds its way. Food is extracted from the circulating water. A network of little flinty spikes, called *spicules*, makes a support to the bodies of many sponges ; in others it consists of horny fibres. The spicules are sometimes composed of carbonate of lime.

The Cœlenterata form the third subdivision of the Animal Kingdom. This word is derived from the Greek *koilos* = hollow, and *enteron* = intestine. The Cœlenterata have internal cavities which serve as stomachs, and these cavities terminate in a mouth, which is fed by means of moving arms or tentacles. The tentacles catch the prey and put it into the mouth, and the mouth passes it on to the stomach, where it is digested.

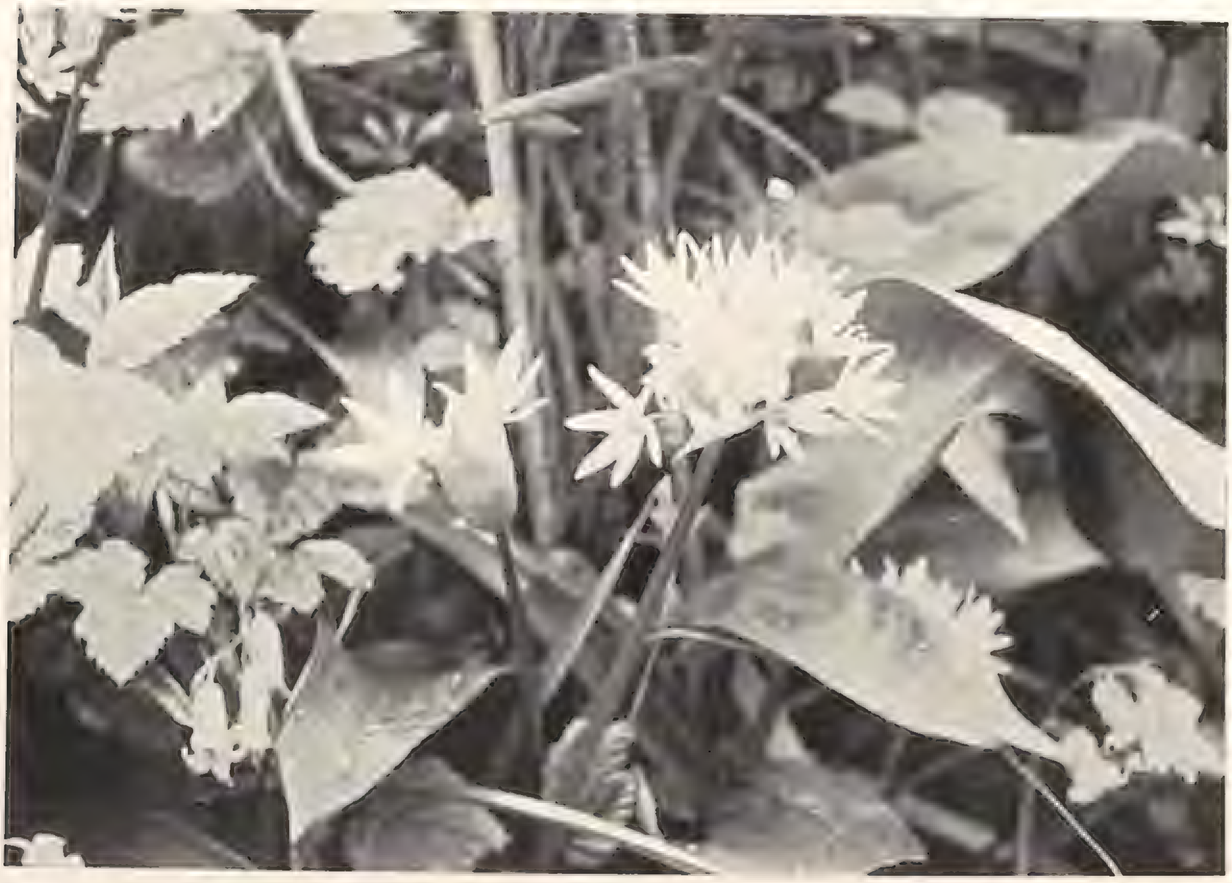
The *Graptolites* (Greek, *grapho* = I write) are known only in fossil forms ; they are found in Cambrian, Ordovician, and Silurian rocks, and these creatures seem to have become extinct at the end of the Silurian Period. The accompanying illustration will give you an idea of the appearance of these fossils. They are found among shales ; many of them have been changed into iron pyrites, which has a glittering, goldlike appearance, and they look like gilded designs on a black background. The graptolites were little colonies of small animals joined together one after the other, each animal living in a tiny horny cup, and all the cups of the colony were connected by a horny skeleton. They get their name from a fancied likeness of some of them to a quill-pen. If you live in a district where graptolites are to be found, I hope you will secure some specimens ; they need careful looking for, and you must not



Song Thrush. *See page* 162.



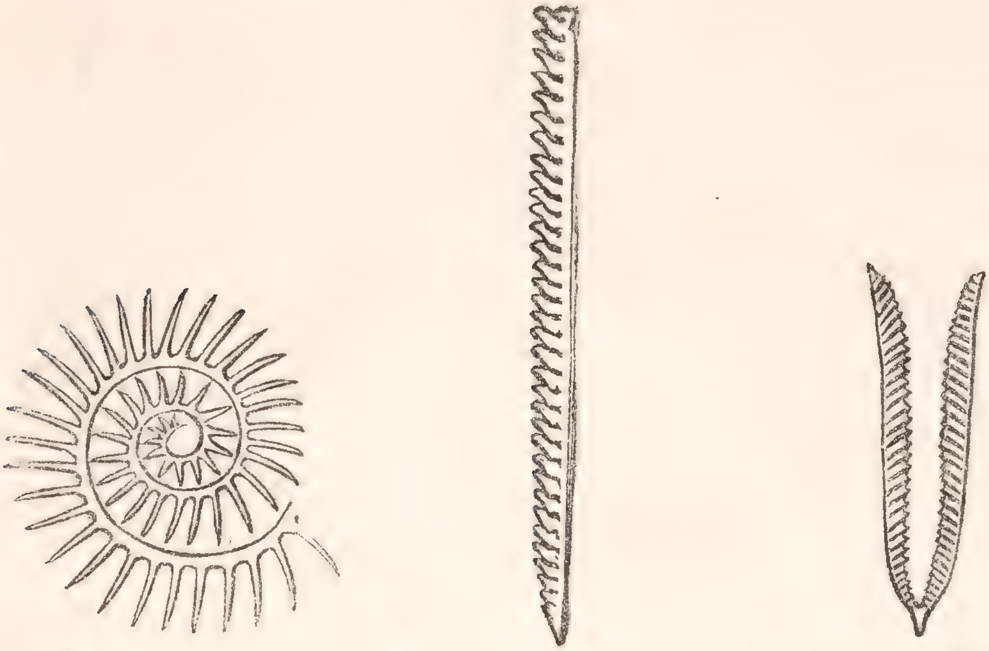
(*a*) Dandelion. *P.* 138.



(*b*) Broad-leaved Garlic. *P.* 145.

mind spending a good time in your search. But you won't mind the passage of time if you are enthusiastic.

Corals form a very important group of the Cœlenterata. I have no doubt you have all seen pieces of what is called "coral," which, however, is but a mass of shells of carbonate of lime which the busy little builders once inhabited. Corals are closely related to sea-anemones, but they are very small animals ; they possess tentacles, which move about in water and catch food ; they also have mouths, gullets, and internal cavities in their soft bodies where food is digested. They extract carbonate of lime from water, and secrete it from their bodies as shells or skeletons. These shells become cemented together when corals live in colonies, and coral reefs are built up in this way by millions of the little

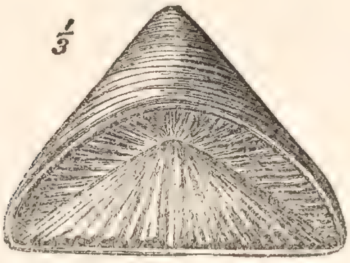


Rastrites peregrinus (Upper Silurian).

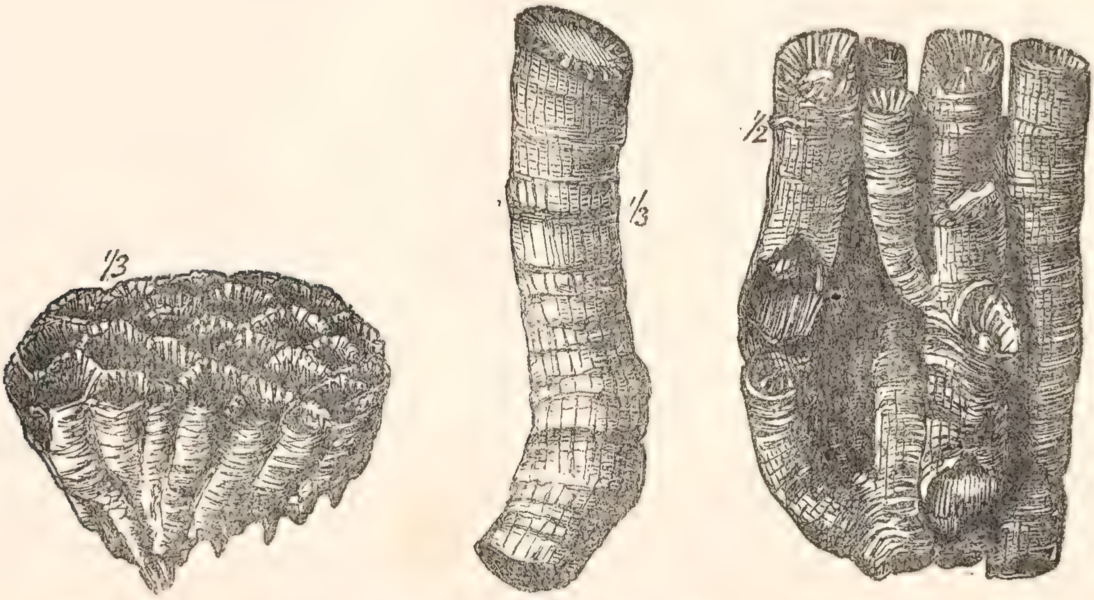
Monograptus priodon (Upper Silurian).

Didymograpsus Murchisonii (Ordovician).

Fig. 9.—Graptolites.



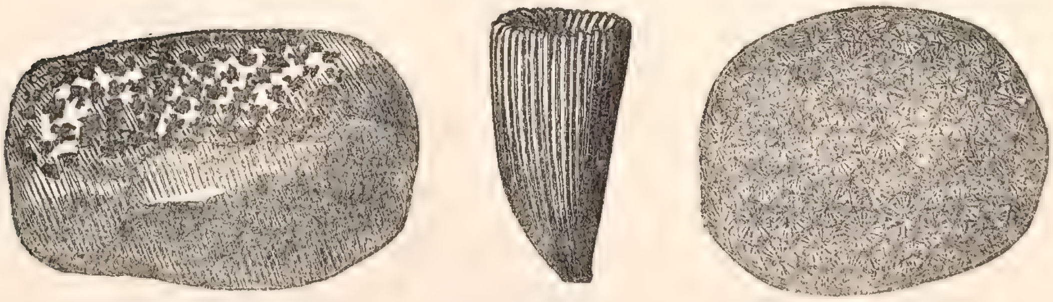
Calceola sandalina (Devonian Rugose Coral).



Michelinia favosa (Carboniferous).

Amplexus coralloides (Carboniferous).

Lithostrotion affine (Carboniferous).



Holocystis elegans (Cretaceous).

Trochocyathus conulus (Cretaceous).

Litharæa Websteri (Eocene).

FIG. 10.—SOME FOSSIL CORALS.

"polyps," as the animals are called. They are not insects, but creatures very much lower in the scale of creation. It is natural that corals, which construct such masses of shells, should have made a goodly contribution to the limestone rocks of the world. Some of the fossil corals differ greatly from the modern reef-building type. The Rugose (wrinkled) corals of the Silurian Age built up thick and rugged walls, and then there are remains of corals which lived as independent individuals, not in colonies, but by themselves. Wenlock Edge, in Shropshire, is a Silurian coral reef. Fossil corals are often found associated with fossil starfish, sea-lilies, worms, and other marine animals. This is what we should expect, for many marine animals flourish on or near coral reefs, and what happens now is likely to have happened when the ancient reefs were in the sea. Various species of fossil corals are to be found in the limestones of all Periods from the Silurian and upwards.

But I must push on, and not enlarge too much, for I have yet a lot of fossils to tell you about.

The ECHINODERMATA (Greek, *echinos* = a hedgehog, *derma* = skin), the creatures which possess spinous or thorny skins, form the fourth subdivision of the Animal Kingdom. I am sure you will be able to think of some of the animals which are included in it. What sea-animals have thorny skins? Why, starfishes and sea-urchins, of course!

Just a few words about *Starfishes*. Perhaps the best example of these animals is the common five-armed starfish, specimens of which you so often see at the seaside. You will be familiar with the starlike appearance, the five arms raying out from the central disc. The mouth is in the centre of the body on the under side. The animal possesses a leathery skin in which are imbedded plates and spines of carbonate of lime. It has tube feet, which are little projections in a groove of the under side of each arm. These feet are filled with a fluid, which is regulated by little sacs, or bladders; when the bladder connected with each foot contracts, it forces fluid into the foot and makes it extend. The feet have ends like suckers, and it is by their means that the animal crawls. It catches prey with its arms, and eats it by extending its stomach out of its mouth and enfolding it—surely a curious way of feeding.

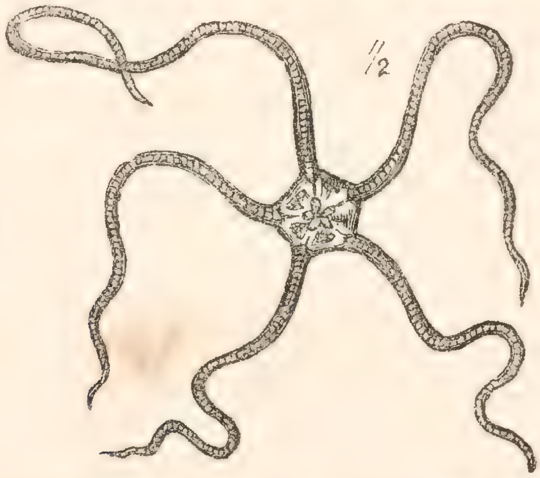
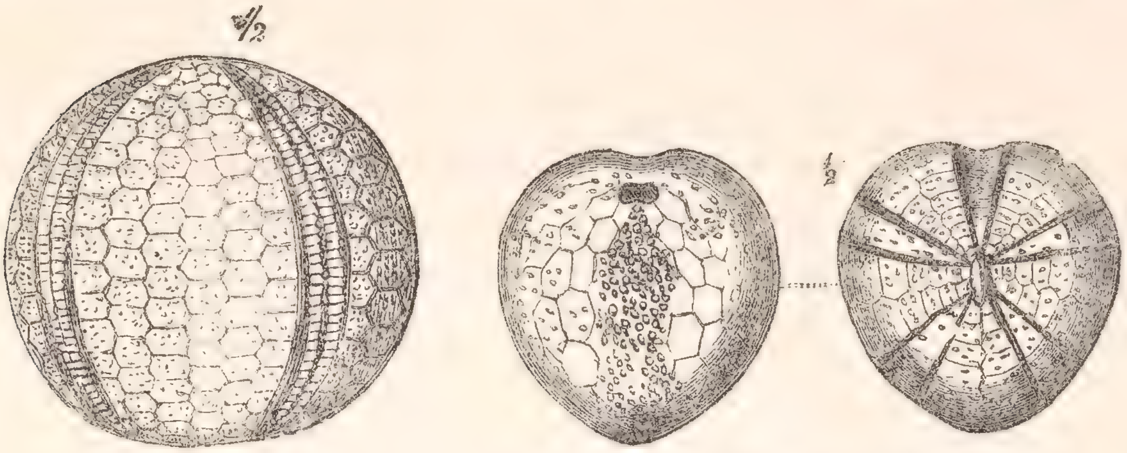


Fig. 11.—Ophioderma Egertoni (a Fossil Brittle-Star).

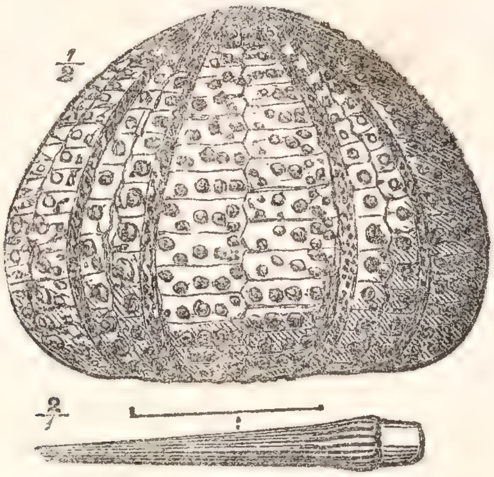
There are also the *Brittle-stars*, near relations of the ordinary starfish. They have long thin arms, but they do not use their tube feet in crawling. They push themselves forward by four of their arms, and, as it were, feel their way with the fifth, which is pushed out in a forward direction. They are called "brittle-stars" because when they are caught by any of their arms, they break away from their enemies, leaving bits of themselves behind them. This is a curious, but effective, method of escape.

Fossil remains of both starfish and brittle-stars are found in some of the oldest strata. They are often in excellent condition, and quite unmistakable. Starfish occur in Cambrian rocks, although not so commonly as in the Silurian strata, in which both they and their relatives, the brittle-stars, are found. These creatures, too, have a long pedigree; their race has existed from Cambrian times until now. Being sea-animals, you will, of course, look for their



Palæchinus sphæricus (Carboniferous).

Holoaster subglobosus (Cretaceous).



Echinus Woodwardii (Pliocene).

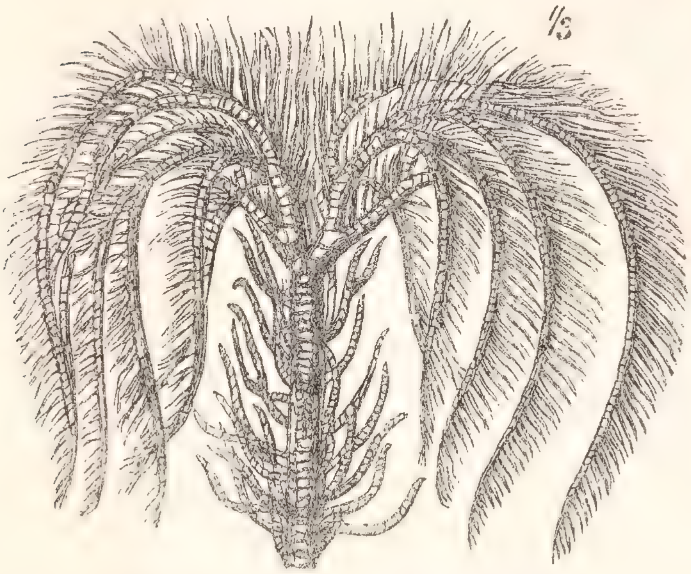
FIG. 12.—FOSSIL SEA-URCHINS.

fossils in rocks, such as limestones, which have been formed in the sea.

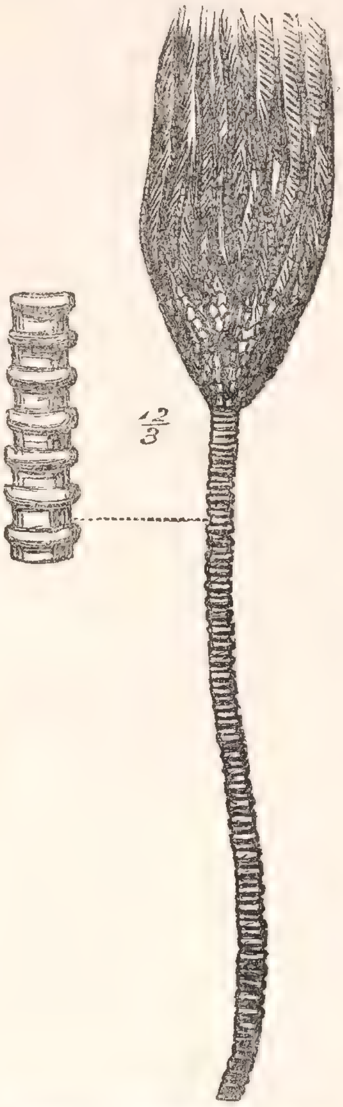
We have not done with the spiny-skinned animals yet. There are the *Sea-urchins*—sea-*merchants* I heard a small boy call them. Their form, too, will be familiar to you. They have globe-shaped, heart-shaped, or flattened, rounded bodies, with no arms. They are enclosed in a shell or skeleton made up of plates of carbonate of lime. Tube feet, similar to those of the starfish, are arranged in five bands, which are well marked on the surface of the shell, and the latter is covered with a great number of socketed spines, forming a protection against enemies. The mouth is central to the under surface, and the rows of tube feet pass from it in regular lines upwards. Fossil sea-urchins are found in sea deposits from the Ordovician Period upwards. Some beautiful species occur in the English White Chalk, which is of the Cretaceous Period.

The Echinodermata also embrace the *Crinoids*, or sea-lilies. These were animals something like star-fish, with long, often subdivided, arms, attached to long stalks. Living species of crinoids are rare, but fossil forms are found quite large in size, and the animals they represent must have been very beautiful. The commonest modern descendant of the ancient sea-lilies is known as the Feather-star, which in the early part of its career lives attached to seaweed, and has the appearance of a small sea-lily; but later it gets rid of its stalk, and swims about by means of its five arms. I have seen limestones of Carboniferous age composed almost entirely of broken stalks and arms of fossil crinoids. Fossil forms of sea-lilies can be traced back as far as Cambrian rocks. The extinct *Cystideans* (Greek, *kystis* = a bladder), fossils of which have been discovered in marine deposits of Cambrian and Silurian Ages, may have been early ancestors of the crinoids. They had rounded or oval, bladder-like bodies, enclosed in plates of lime, with just the beginnings of arms and short jointed stalks.

Higher still in the scale of life-forms we have the fifth great subdivision, the VERMES (Latin, *vermis* = a worm). Worms are more highly developed creatures than any we have yet considered. They possess jointed bodies and nervous systems; they also have an internal digestive canal and a number of organs. Few of the worms are found in a fossil



Extracrinus Briareus (Jurassic).

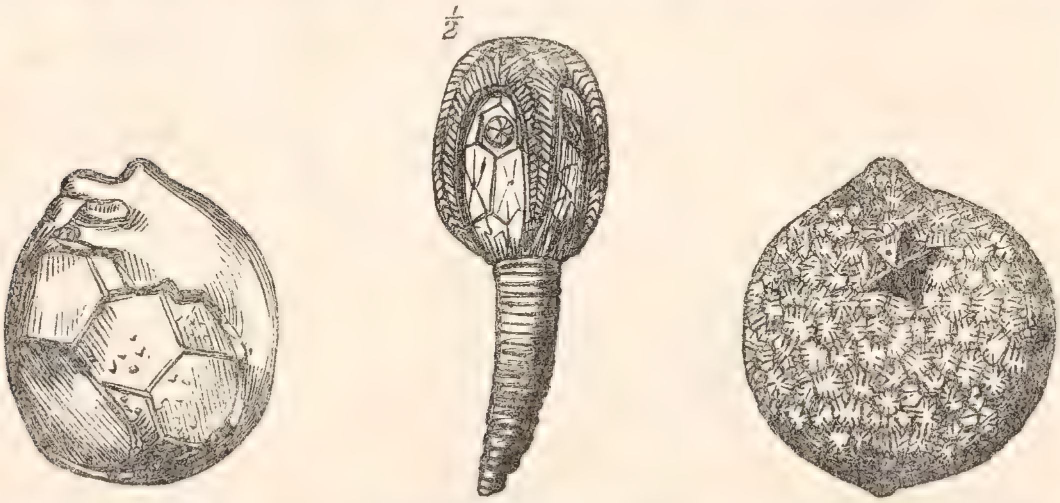


Periechocrinus moniliformis (Silurian).

FIG. 13.—FOSSIL SEA-LILIES OR CRINOIDS.

state. Some of them live in tubes of lime, and such worm-tubes are sometimes discovered as fossils. You often see worm-tubes on stones and shells on the seashore, but they, of course, are not fossils. Burrows and trails of worms occur in some very old rocks.

The next subdivision that we have to consider is that of the Arthropoda (Greek, *arthron* = a joint, *podos* = a foot). This great subdivision includes Crabs, Lobsters, Spiders, Insects, Scorpions, Centipedes, etc. All these animals' bodies are divided into a number of segments, each segment bearing a pair of limbs, and the limbs are usually jointed. The animals also have elaborate digestive, circulatory, and nervous systems. Their fossil remains are widely distributed.



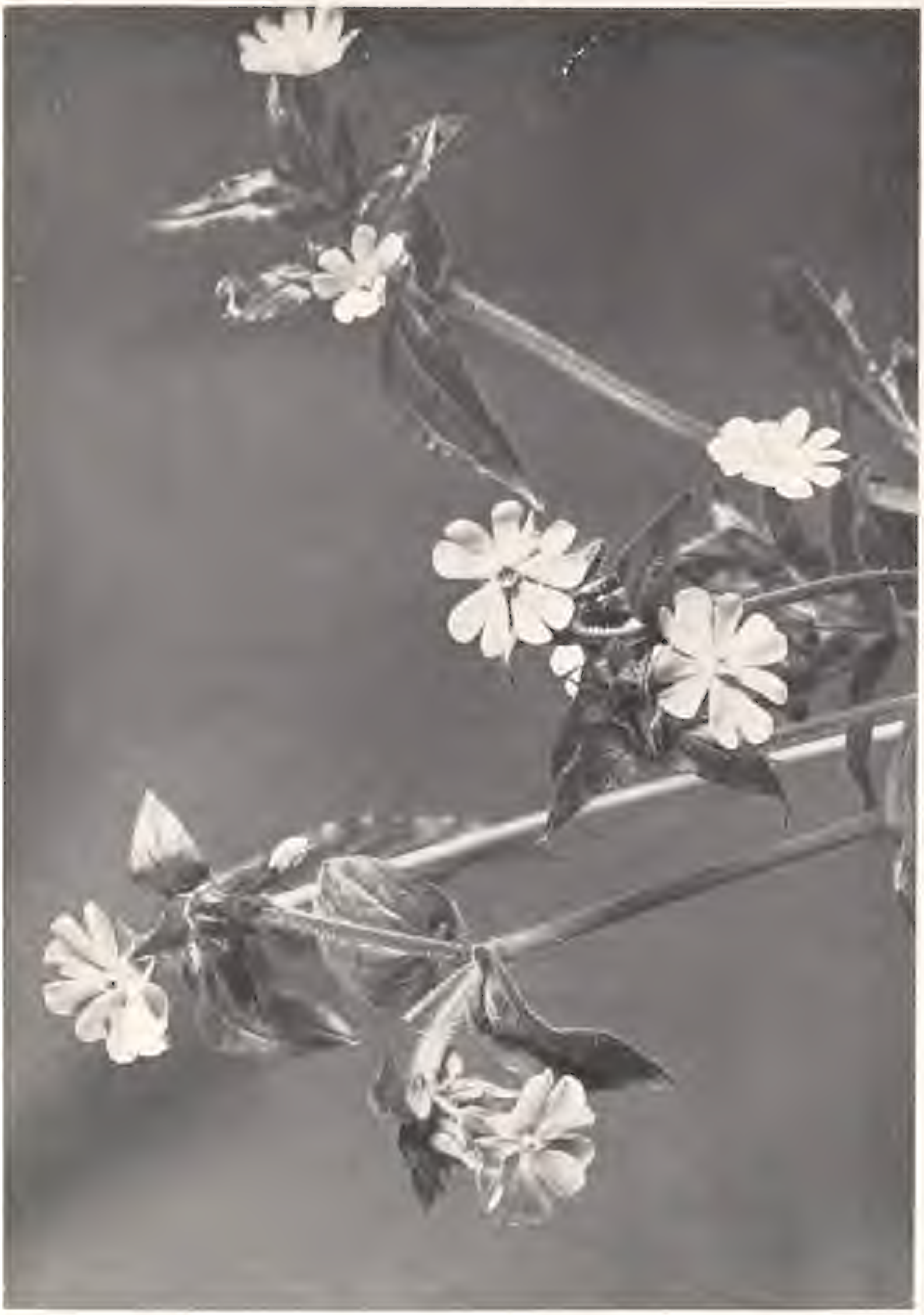
Sphæronites Litchi (Ordovician). *Pseudocrinites quadrifasciatus* (Silurian). *Echinosphærites aurantium* (Ordovician).

Fig. 14.—Fossil Cystideans.

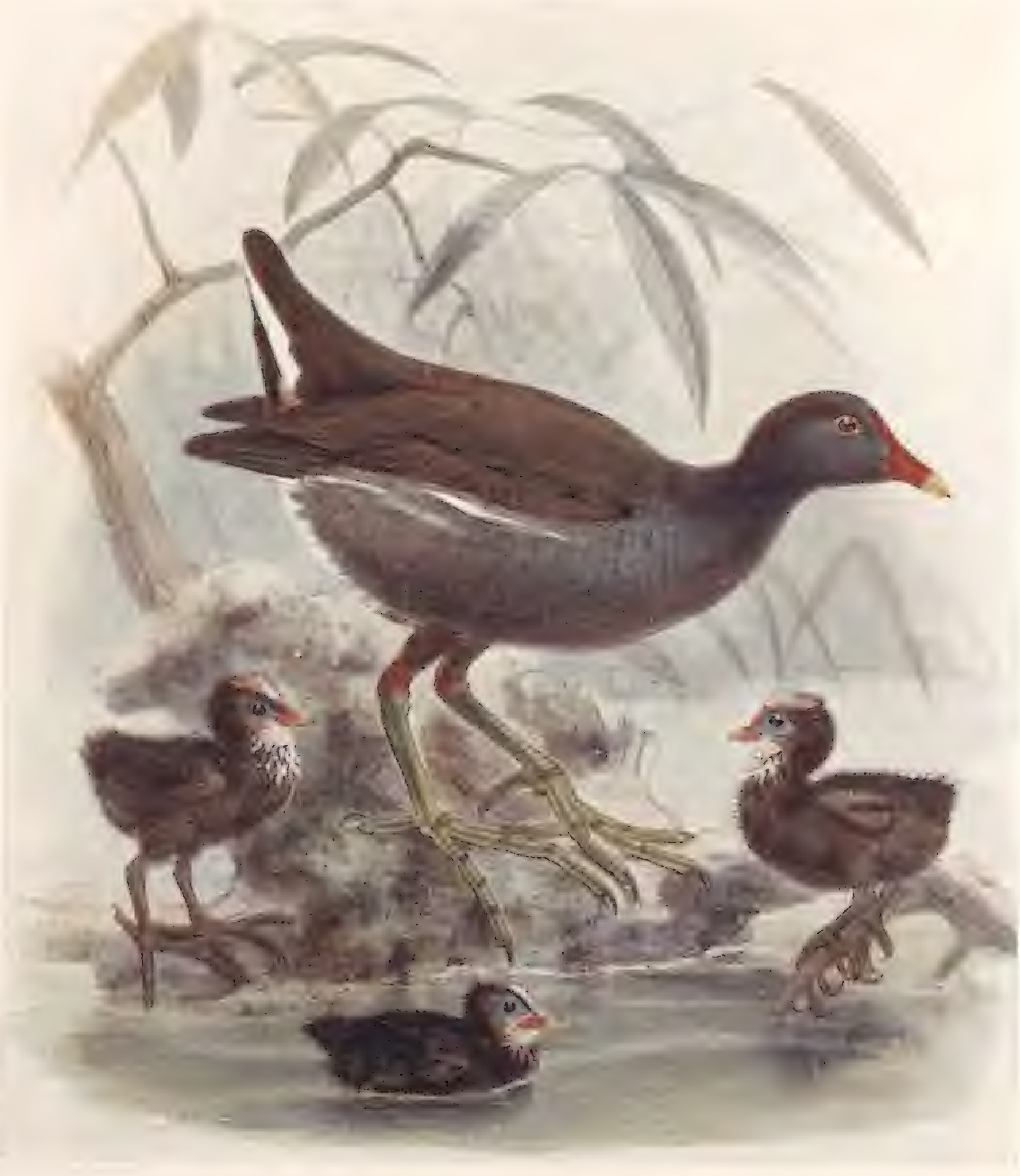
This sub-kingdom is arranged into four great classes :

1. *Crustacea* (Latin, *crusta* = a rind).—Head and thorax united and covered with a carapace—that is,

PLATE 18

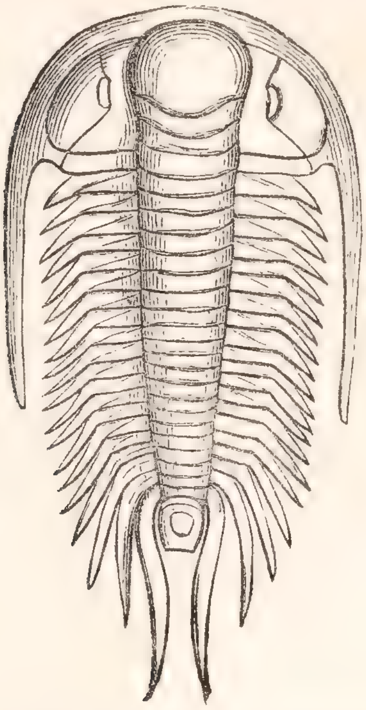


RED CAMPION. *P.* 142.

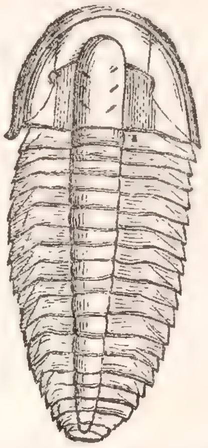


MOORHEN. *See page* 159.

a shield like the shell of a crab. Appendages numerous. Two pairs of feelers. Possessing gills, by which they breathe. Examples: Crabs, Lobsters, Crayfish, Barnacles, Wood-lice, Water Fleas, and Shrimps. *Trilobites*, so called because they are three-lobed, became extinct very long ago. Fossil remains of them are found in Cambrian deposits, and occur from that Period up to Permian strata. These animals were in some cases nearly two feet long, but others were small.



Paradoxides Davidis.



Conocoryphe Lyellii.

FIG. 15.—TRILOBITES OF CAMBRIAN AGE.

They probably lived in great numbers on muddy and sandy sea-floors, as their fossils are common in some shales and sandstones. The Jurassic Crustacean known as *Scapheus ancylochelis* — I know of no English name for it—is said to be a step in the direction of living crabs, but an older set of Crustaceans, known as *Eurypterids* (Greek, *eurys* = broad, and *pteron* = fin), constituted an earlier stage of development between the trilobites and crabs. The *Pterygotus* (Greek, *pteryx* = a wing, *ous* (otos) = an ear), which is found in fossil form in Silurian and Devonian rocks, was a big Crustacean. A specimen was discovered by the celebrated geologist, Hugh Miller, at Carmyle in Forfarshire. It measured nearly six feet long and over a foot across. By the way, if my young readers want some geological inspiration, they should read the "Life" of Hugh Miller, and some of his writings, particularly "The Old Red Sandstone."

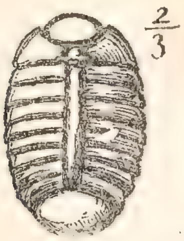


FIG. 16.—ARCHÆONISCUS EDWARDSI.

A fossil Wood-louse (Jurassic).

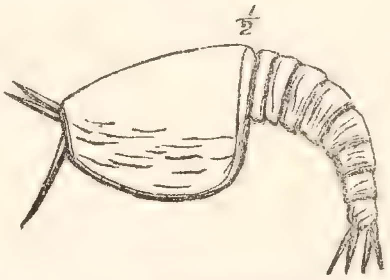


FIG. 17.—HYMENOCARIS VERMICAUDA.

A fossil Cambrian shrimp-like animal.

2. *Myriapoda* (Greek, *myrios* = numberless, *pous* = a foot).—Animals with many segments, distinct heads, wormlike bodies, and many legs. They breathe by means of organs known as tracheal tubes. They have a pair of feelers called "antennæ." Examples: Millipedes and Centipedes. Fossil remains of millipedes, which must have lived on decayed wood, have been found in the Scottish Lower Old Red Sandstone (Devonian Period), and also in rocks of Carboniferous Age. Both centipedes and millipedes are vegetarians, and quite harmless: they are land animals.

3. *Insects.*—Body divided into segments, head, thorax, and abdomen. Head has pair of feelers. Thorax bears three pairs of legs. Body protected by a hardened skin. Breathing tracheal. Examples: Grasshoppers, Crickets, May-flies, Bugs, House-flies, Butterflies and Moths, Beetles, Ants, Bees and Wasps. Numerous fossil insects have been discovered. In the Old Red Sandstone an old form of may-fly has been unearthed; its wings measured no less than five inches across their spread. The Carboniferous strata yield ancient species of White Ants, Crickets, Stone-flies, and Cockroaches. Big Dragon-flies must have flourished in that Period. The Triassic seam known as Cotham Stone in England contains an abundance of fossil insect wings and wing-cases. Grasshoppers throve in the Triassic Period, in addition to dragon-flies and may-flies. The Purbeck Beds, which are found in the Isle of Purbeck, and are of Jurassic Age, yield fossils of numerous insects. We owe the preservation of some insects to their having been caught in resins exuded from trees. The resin has become fossilized, and in its fossil condition is known as *Amber*. Perhaps you have seen a specimen of amber with a fly embedded in it. In Miocene times insect life was probably more varied in some respects than it is now—at least, fossils of Miocene insects found in Switzerland seem to point to such a conclusion. What a happy hunt-

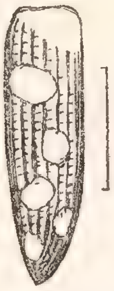
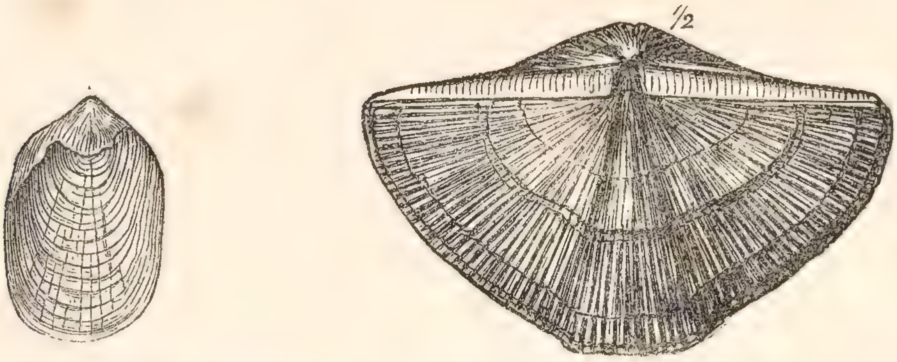


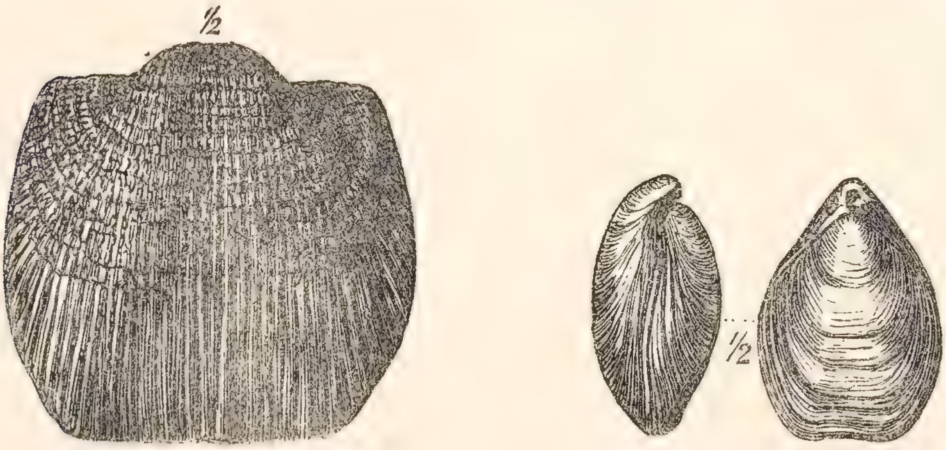
FIG. 18.—BUPRESTON STYGNUS.

Fossil wing-shield of a beetle, from Jurassic strata.

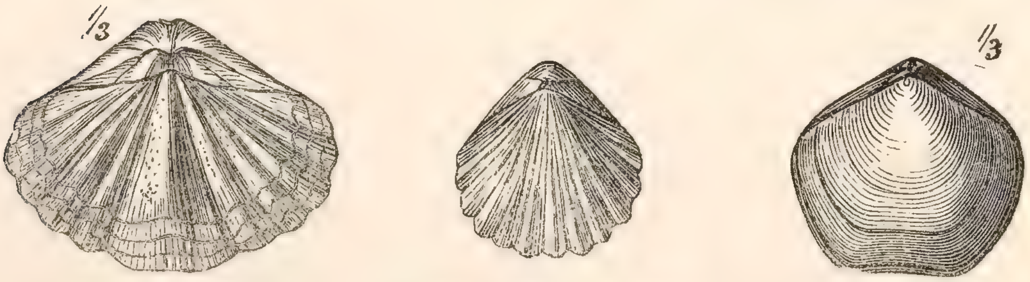
ing-ground for the insect collector! But, alas! insect collectors—that is, human ones—did not



Lingulella ferruginea (Cambrian). *Spirifera striata* (Carboniferous).



Producta semireticulata (Carboniferous).
Terebratula hastata (Carboniferous).



Spirifera Walcottii (Jurassic).
Rhynchonella rimosa (Jurassic).
Terebratula numismalis (Jurassic).

Fig. 19.—Some Fossil Brachiopods.

live then, and the modern insect hunter has to be content with Miocene specimens in a fossil form. I have no doubt, however, that insects in all ages have been hunted extensively; they must always have had plenty of natural enemies anxious to prey upon them.

4. *Arachnida* (Greek, *arachnē* = spider). — Head and thorax joined, and covered with a carapace. Four pairs of walking legs. No proper feelers. Breathe by lung-sacs. Examples: Spiders, Mites, and Scorpions. Spiders are familiar animals, and I shall not attempt to describe them. Scorpions have two pairs of limbs, one of them large and the other much smaller, ending in crablike nippers, which take the place of jaws. If you have learned some astronomy, you will bear in mind that one of the constellations was named by the ancients after the scorpion. There are fossil scorpions very similar to living species, and some of them have been wonderfully well preserved, so well that an unskilled person having seen a modern specimen could not fail to know a fossil one. Up to the year 1884 no land animal remains had been found in Silurian rocks, but in that year some fossil scorpions were discovered in Silurian strata of Scotland, the United States, and Sweden. If creatures so well advanced in the scale of life as scorpions existed in Silurian times there must then have been a large variety of animal life, in spite of the fact that so few remains have been preserved. The Carboniferous rocks of Scotland have yielded great numbers of scorpions; they may be found in the shales in excellent condition.

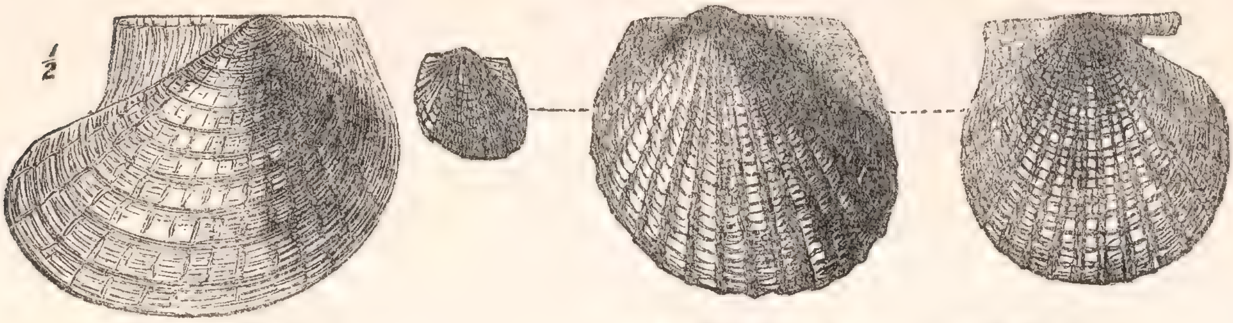
Before passing on to the Mollusca, or the shellfish proper, mention must be made of the MOLLUSCOIDEA, which have soft, unsegmented bodies bearing a coating of horn or lime. This class includes the *Brachiopoda*, which have double shells, one half of which is larger than the other. The animal lives in the lower and larger half, and uses the upper half, or valve, as a cover. From the creature's mouth two arms extend, and these arms capture food. The word Brachiopod is from the Greek (*brachion* = arm, and *pous* = foot). The *Terebratula*, called the "lamp-shell" on account of its likeness to an ancient Roman lamp, is an existent member of the class. There are few living brachiopods, but in early geological times the species were numerous, as the rocks testify, and their fossil remains form a very important group (see illustrations in Fig. 19).

The MOLLUSCA (Latin, *mollis* = soft) are soft-bodied animals, generally with no internal skeleton, and usually having shells lined with a membrane called the "mantle." The Mollusca are of three classes—namely, Lamellibranchia, Gasteropoda, and Cephalopoda. These, I admit, are terrible names, but when we know the meaning of them we can see how descriptive they are.

1. *Lamellibranchia* (Latin, *lamella* = a little plate, and *branchiæ* = gills).—Oysters, Cockles, Mussels, Clams, etc., are members of this class. They are called "bivalves," because their shells consist of two valves of the same size. The shells are lined with two-lobed mantles, and each animal has a foot enabling it to move about. They are gill-breathers. Fossil species are found in strata ranging from the Cambrian Period, from which time they appear to have gradually increased in numbers up to

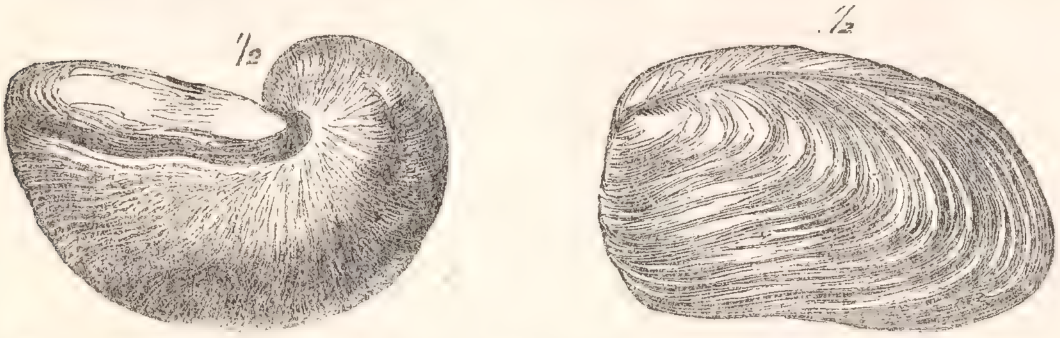
the present, when we have a great number of species representing many families (see Figs. 20 and 21).

2. *Gasteropoda* (Greek, *gaster* = a belly, *pous* = a foot).—Principal features: A univalve shell, generally spiral, and a single-lobed mantle. Flat feet. Well-developed heads, with eyes, and a tonguelike organ called an "odontophore" (Greek, *odontos* = a tooth). Examples: Garden-snails, Whelks, Periwinkles, Limpets, etc. Fossil Gasteropods range from Cambrian times. The Cambrian Lingula-flags of Wales yield specimens of the genus *Bellerophon*. Nearly 1,300 species have been found in Silurian rocks, so you see if you devote yourselves only to the study of fossil Gasteropoda you will have your work cut out (see Fig. 22)!



Avicula Danbyi (Silurian).

Avicula decussata (Jurassic).

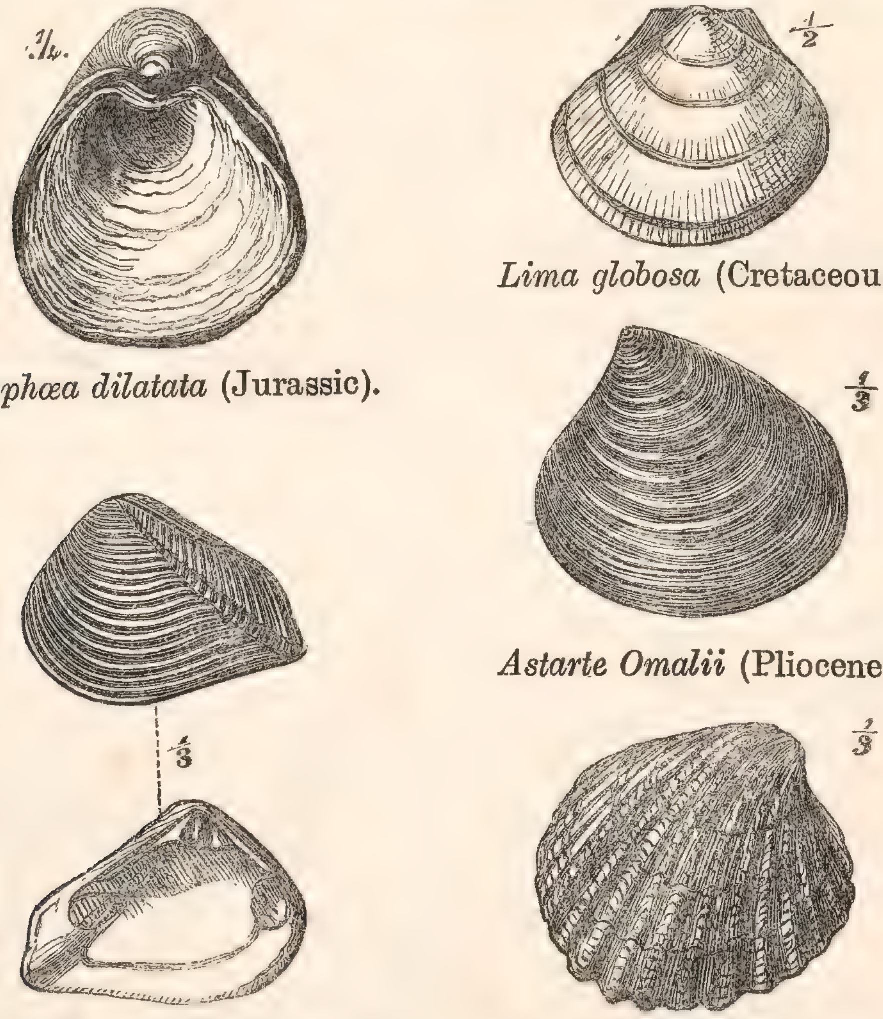


Gryphœa incurva (Jurassic).

Hippopodium ponderosum (Jurassic).

FIG. 20.—SOME FOSSIL LAMELLIBRANCHS, OR BIVALVES.

3. *Cephalopoda* (Greek, *kephale* = the head, and *pous* = a foot).—The feet of animals of this class are round the head, hence the name. The mouth is surrounded by tentacles or arms, which bear suckers. They breathe by plumelike gills. Examples : Cuttle-fish and Nautili. Existing species of this class are mostly destitute of a shell, although one is possessed both by the Paper Nautilus and the Pearly Nautilus. Some have an internal skeleton or bone, which in some is horny, and in others made of lime. Well-developed heads and eyes. The cuttle-fish can swim



Lima globosa (Cretaceous).

Gryphœa dilatata (Jurassic).

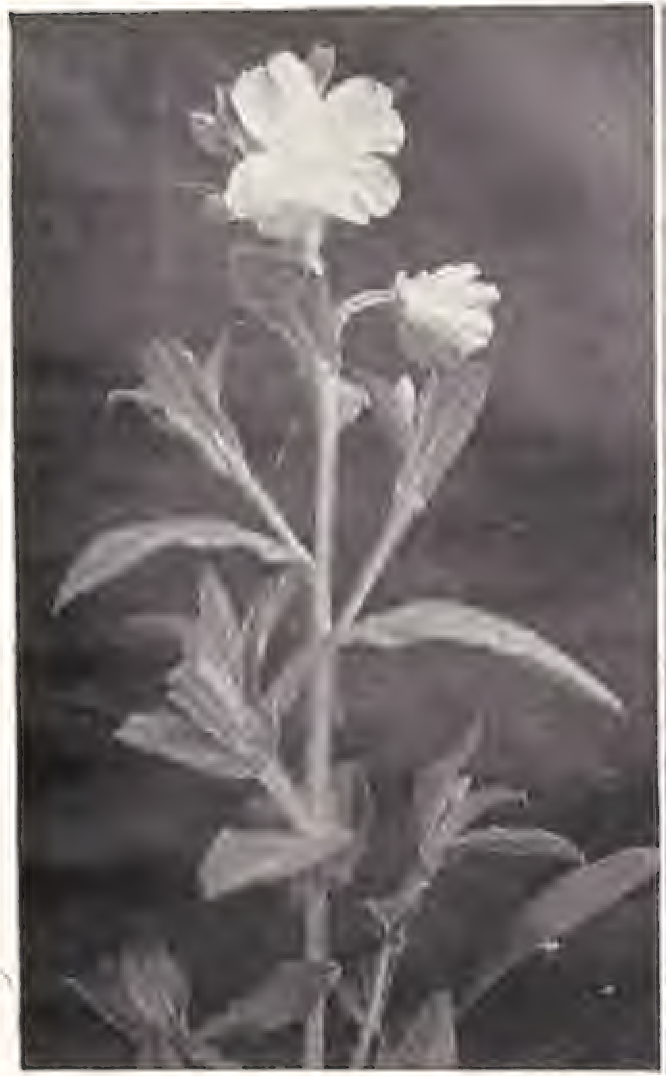
Astarte Omalii (Pliocene).

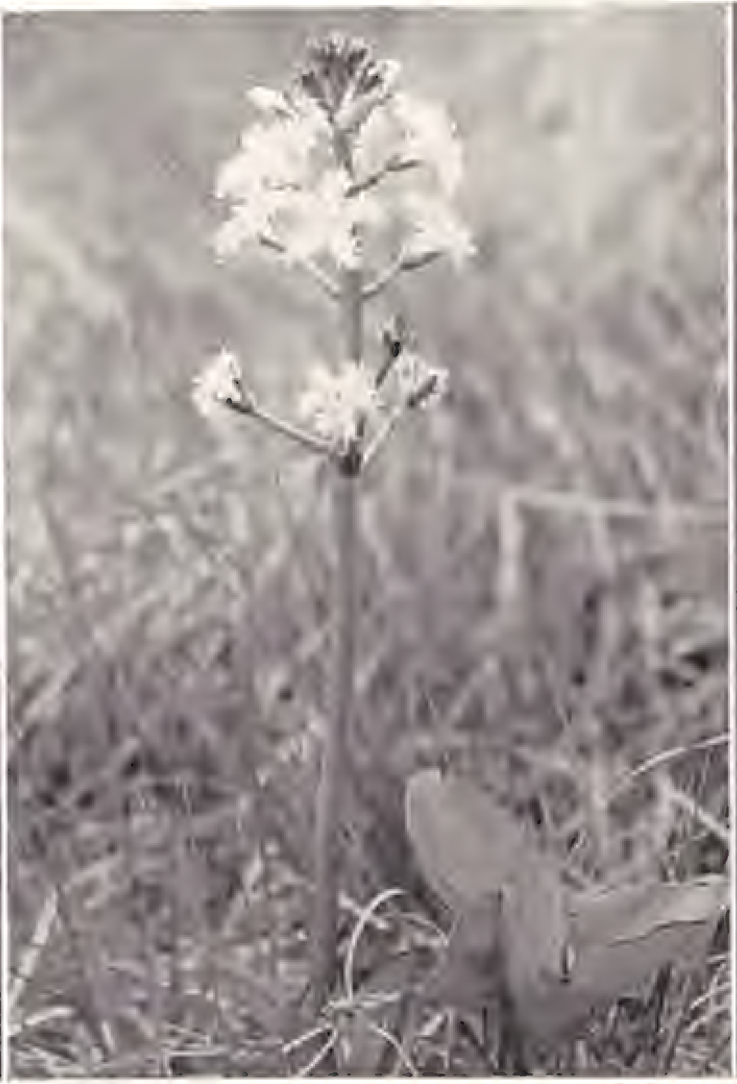
Crassatella sulcata (Eocene).

Cardita senilis (Pliocene).

FIG. 21.—MORE FOSSIL LAMELLIBRANCHS, OR BIVALVES.

PLATE 20


(*a*) Codlins-and-Cream. *P.* 143.


(*b*) Buck Bean. *P.* 143.

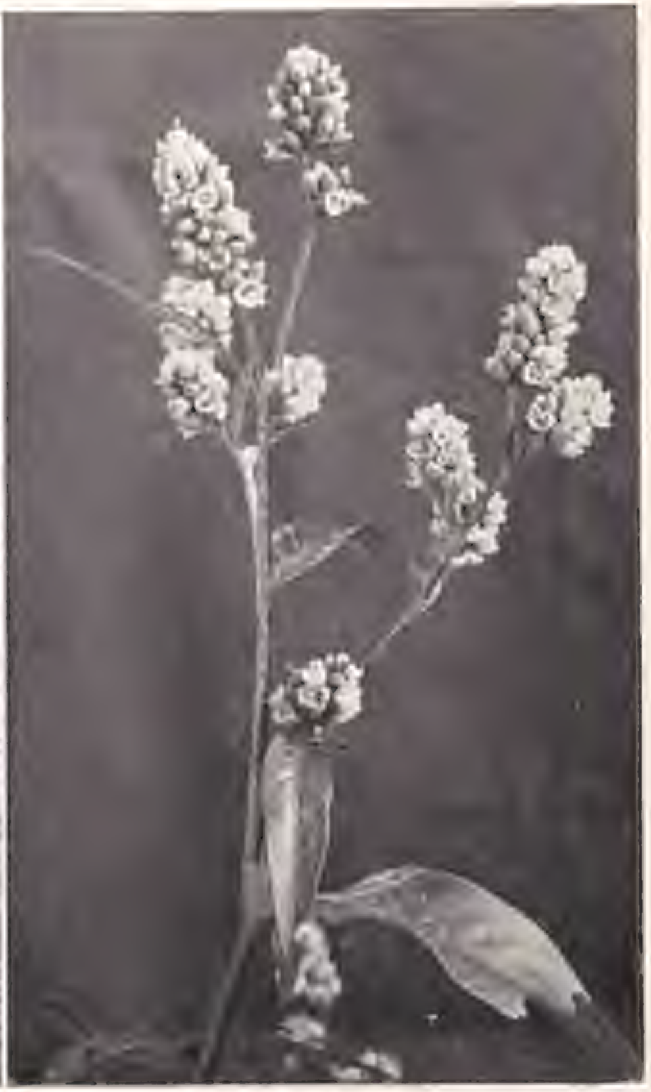
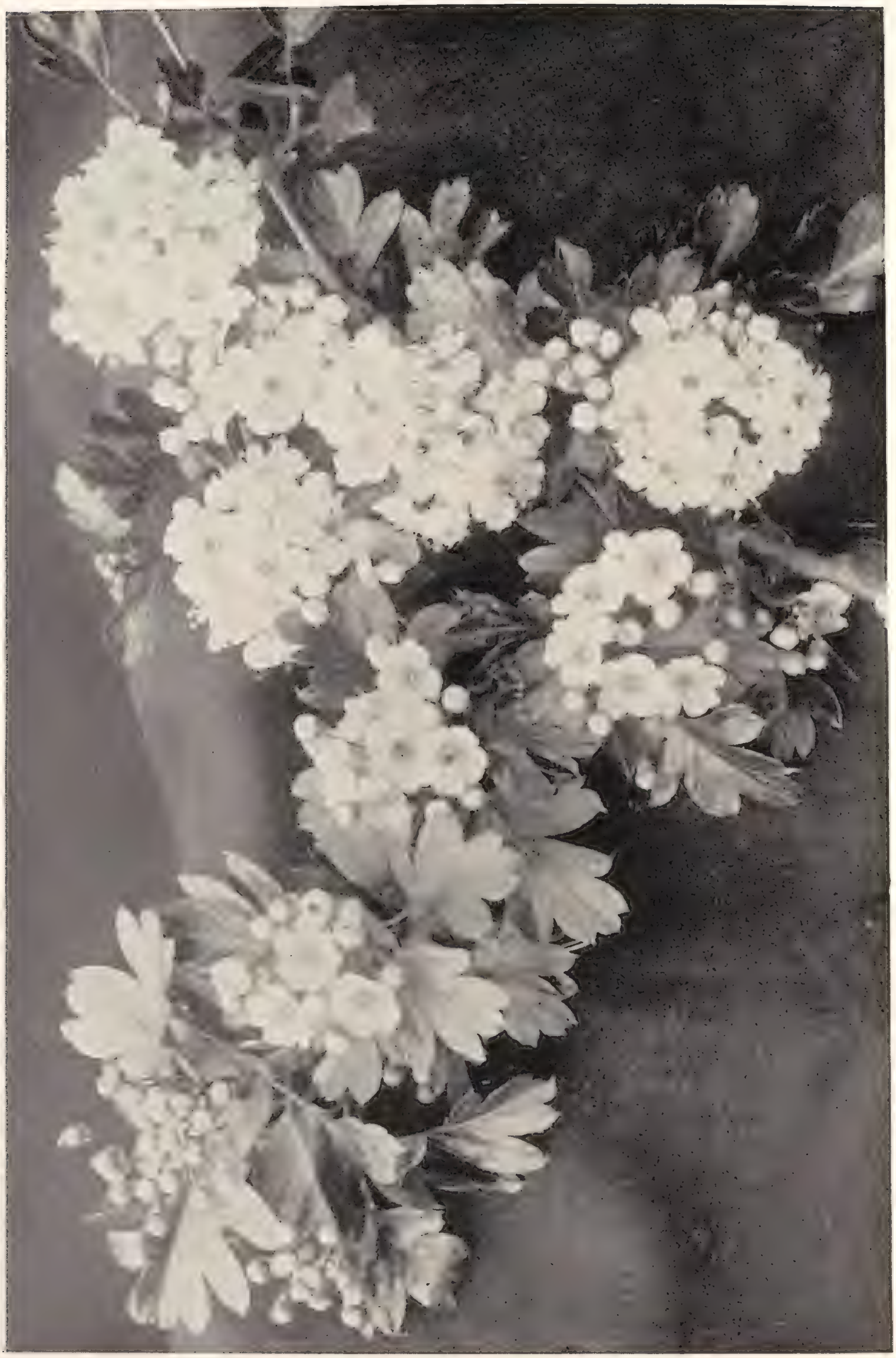
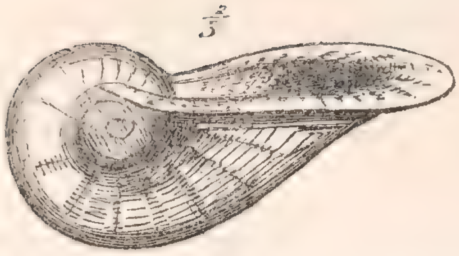

(*c*) Spotted Persicaria. *P.* 144.

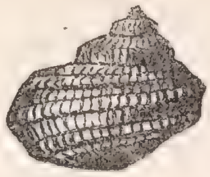
PLATE 21



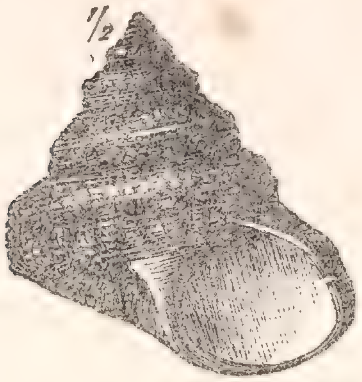
HAWTHORN. *P.* 157.



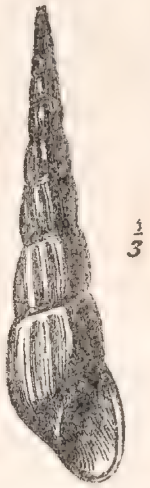
Bellerophon dilatatus (Silurian).



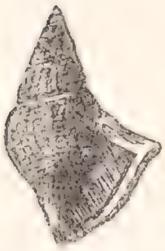
Pleurotomaria aspera (Devonian).



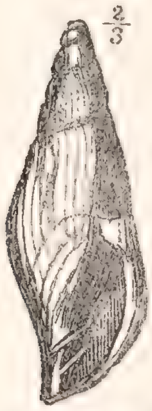
Pleurotomaria Anglica (Jurassic).



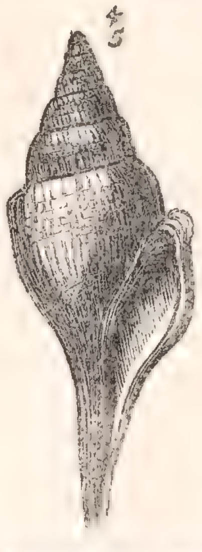
Scalaria Gaultina (Cretaceous).



Aporrhais Sowerbii (Eocene).



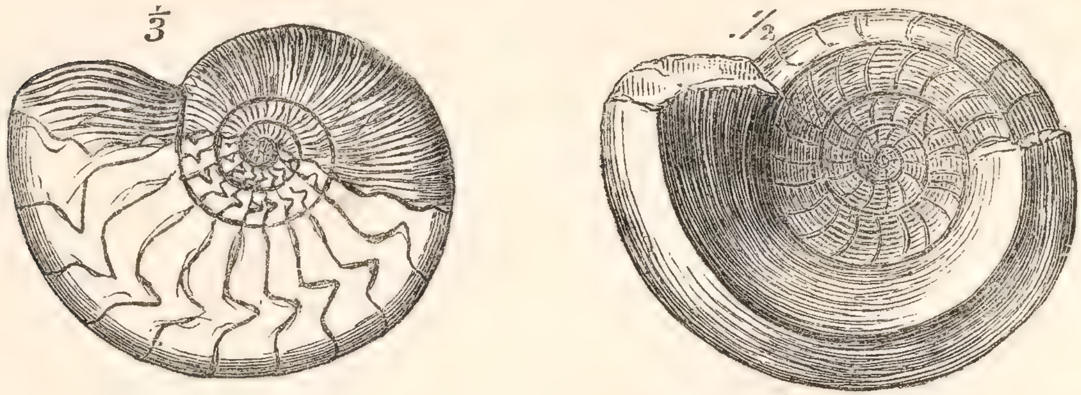
Voluta Wetherellii (Eocene).



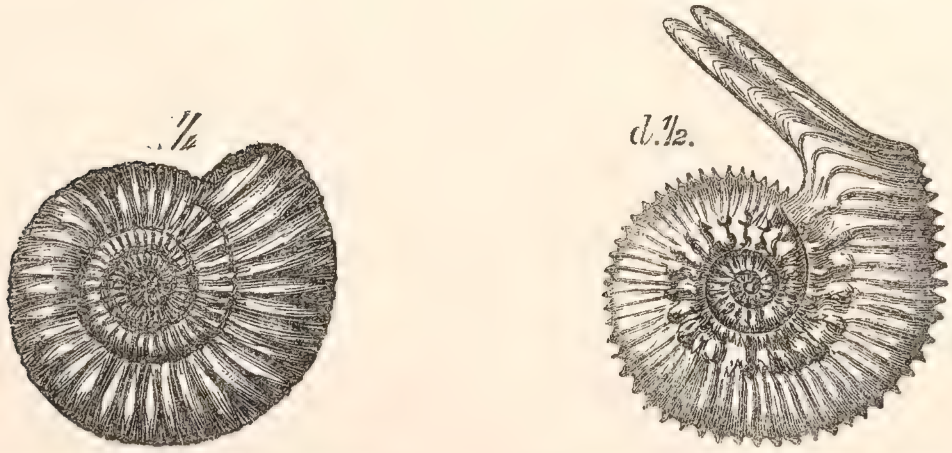
Fusus longævus (Eocene).

Fig. 22.—Some Fossil Gasteropods or Univalves.

backwards, and when attacked by an enemy can make the water near it cloudy by ejecting a kind of ink (sepia); it can escape under cover of the inky water. Naturally only the hard parts of such Cephalopods are preserved in fossil form. This class of animal was far more abundant in former geological periods than it is now. Many of the extinct kinds possessed shells, so that fossil remains are numerous.



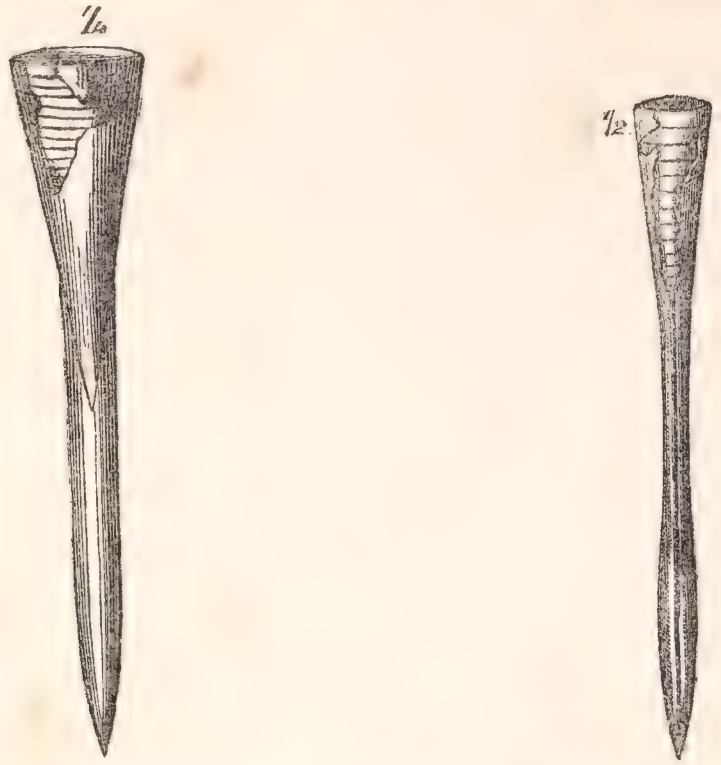
Clymenia striata (Devonian). *Nautilus cariniferus* (Carboniferous).



Ammonites communis (Jurassic). *Ammonites Jason* (Jurassic).

FIG. 23.—SOME FOSSIL CEPHALOPODS.

It would seem that in very early times the Cephalopods were the masters of the sea. Like the rest of the Mollusca, their fossils range from Cambrian times, but they are not well represented in the strata of that Period. They appear in increasing numbers and forms in Silurian, Devonian, and Carboniferous rocks. Newer types are found in Permian strata, and species occur in open-sea deposits of Triassic age in wonderful abundance. These deposits are found on the Pacific coasts of North America, also in the Eastern Alps and Western Thibet. The Cephalopods seem to have increased and flourished until the Cretaceous Period, in whose rocks the fossil remains are numerous and greatly varied. After that period their vitality seems to have ebbed, and many forms became extinct.



Belemnites elongatus. *Belemnites hastatus.*

FIG. 24.—BELEMNITES, INCORRECTLY CALLED "THUNDERBOLTS."

The two forms of Cephalopods known as *Belemnites* and *Ammonites* may have been brought to your notice already. I remember being greatly interested in them when I was a small boy. Belemnites were commonly found among the gravels with which roads were made in the neighbourhood of Peterborough, where I then lived. People used to tell me that they were "thunder-bolts," a statement which aroused my curiosity greatly, but about which I was sceptical. In time I learned that these curious fossils are the remains of extinct cuttle-fish, being their "pens," or internal shells. I used to find ammonites as well, and was told that they were petrified snakes. This, however, is not the case, for in truth ammonites are fossil Cephalopods closely related to the modern pearly nautilus, which is found in the Pacific and Indian Oceans. The shell of the nautilus has many chambers, but the animal lives in the last and largest; as one might say, it views life through the front door. The remaining chambers are filled with gas, which reduces the animal's weight in water, and enables it to crawl or swim the more easily. The few species of nautilus which now exist are the only surviving relatives of the numerous ancient ammonites and nautili. Ammonites flourished exceedingly in the Mesozoic Era, and their remains are characteristic of the Mesozoic rocks in which many species are found, some of them of great size, being about five feet in diameter. But the majority are comparatively small. Plenty of ammonites can be got in the English chalk. The genus *Nautilus* had ancestors as far back as Silu-

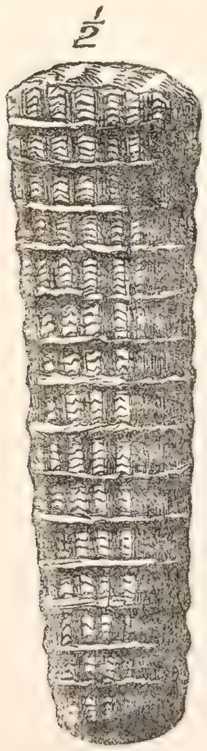
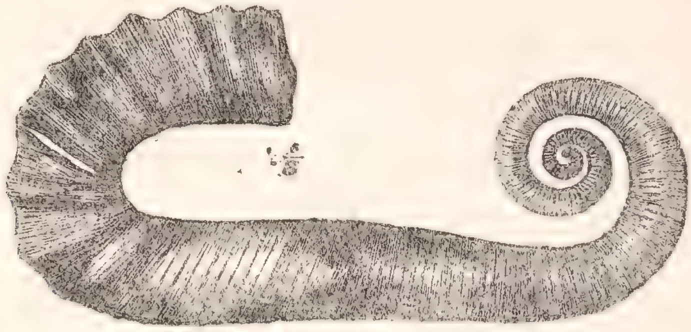
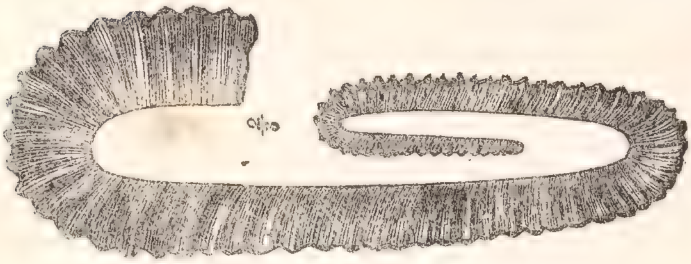


FIG. 25. — ORTHOCERAS ANNULATUM (SILURIAN).

rian times. Some chambered Cephalopods known as *Orthoceratites* (Greek, *orthos* = straight, and *keras* = horn) existed in the Cambrian Period. As their name implies, they were straight, not coiled (see Fig. 25). Perhaps they stand as memorials of a very early stage in the development of the nautilus kind. It is quite likely that the animals found themselves clumsy in a straight position, and discovered it to be advantageous to coil themselves up. The coil may have been gradually developed through many ages of effort in that direction. Another ally of the nautilus was the Ancyloceras (Greek, *ankylos* = incurved), in which one end of the shell is loosely coiled, and the other curved inwards like a hook. Fossil remains of this animal are found in Cretaceous strata. Then there were other Cephalopods whose shells were



Ancyloceras gigas (Cretaceous).



Hamites attenuatus (Cretaceous).

FIG. 26.—ANCYLOCERAS AND HAMITES.
Fossil Cephalopods.

twisted into long spires; they are called *Turrilites* (Latin, *turris* = a tower). Still others were hooked, but not coiled at one end like Ancyloceras; they are called *Hamites* (Latin, *hamus* = a hook). Both kinds flourished in Cretaceous times (see Figs. 26 and 27).

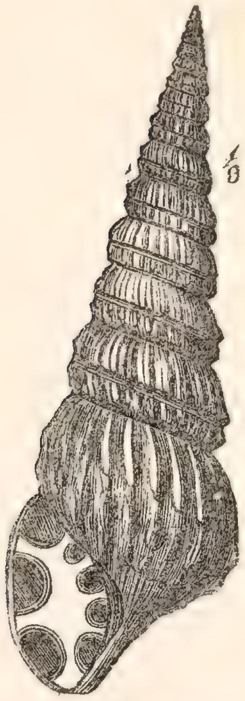


Fig. 27.—Turrilites costatus (Cretaceous).

This chapter is sufficiently long, and I have found my space all too short. I had hoped to condense all I wished to say about fossils into one chapter, but this turns out to be an impossible task. I must therefore continue the subject in another chapter, in which I shall give you a short account of some of the higher forms of life which are found in fossil conditions. When I come to tell you about some of the extinct monsters I am sure you will think that I have introduced you into the wonderland of geology. If you have followed the present chapter carefully and intelligently, you will have learned that the earth has been inhabited from a far, far time by hosts of curious and interesting animals. Indeed, it is difficult for us to imagine a time when the earth had no occupants, although such a condition of things must have existed incalculable ages ago.

By the way, I ought to have told you that the study of fossils is called "Palæontology" (Greek, *palaios* = ancient, *onta* = existences).

CHAPTER IV

MORE ABOUT FOSSILS

THE last chapter conveniently concluded our study of fossils with the last sub-kingdom of the invertebrate or backboneless animals, the Mollusca. We shall now proceed to deal with the eighth great sub-kingdom, the VERTEBRATA, or *Cordata*, the members of which can be easily recognized by their possession of backbones and nerve-cords. The Vertebrata are divided into five leading classes :

1. *Fishes*.—Animals which breathe by gills, and are cold-blooded. They have their bodies covered with scales, and their limbs, when present, appear in the form of fins. Fossil fish are found in Upper Silurian strata, and they constitute the earliest traces of vertebrate life-forms which have been discovered. Some Old Red Sandstone rocks of the Devonian Period contain great numbers of fish remains. In some flagstones and sandstones of that age fossil fish are found piled up on each other, and in a well-preserved condition. It would seem as if shoals of the fish had met with a sudden death, and their bodies had been covered by sediments very quickly, before they could decay or be destroyed.

The celebrated Hugh Miller has told us about his discovery of the *Pterichthys,* or winged fish, at Cromarty in the year 1831. It is called *Pterichthys Milleri* in honour of its discoverer. I had better tell you the story in his own words. He says: "Had Lamarck (a famous student of palæontology, who lived from 1744 to 1829) been the discoverer he would have held that he had caught a fish almost in the act of wishing itself into a bird. There are wings which want only feathers, a body which seems to have been as well adapted for passing through the air as in the water, and a tail by which to steer. . . .

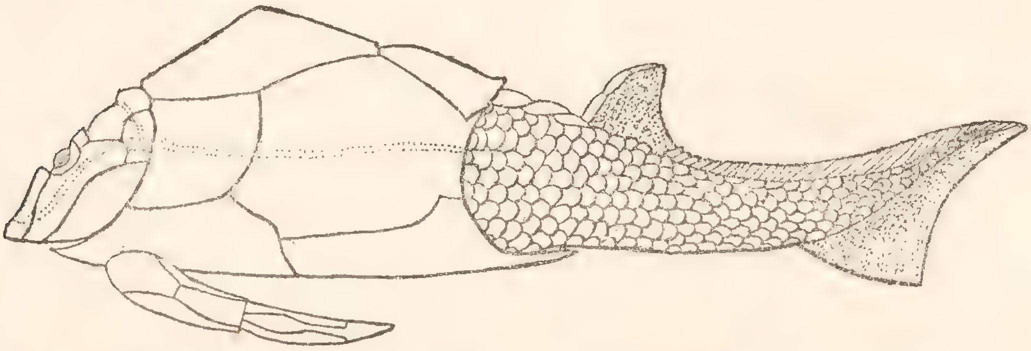
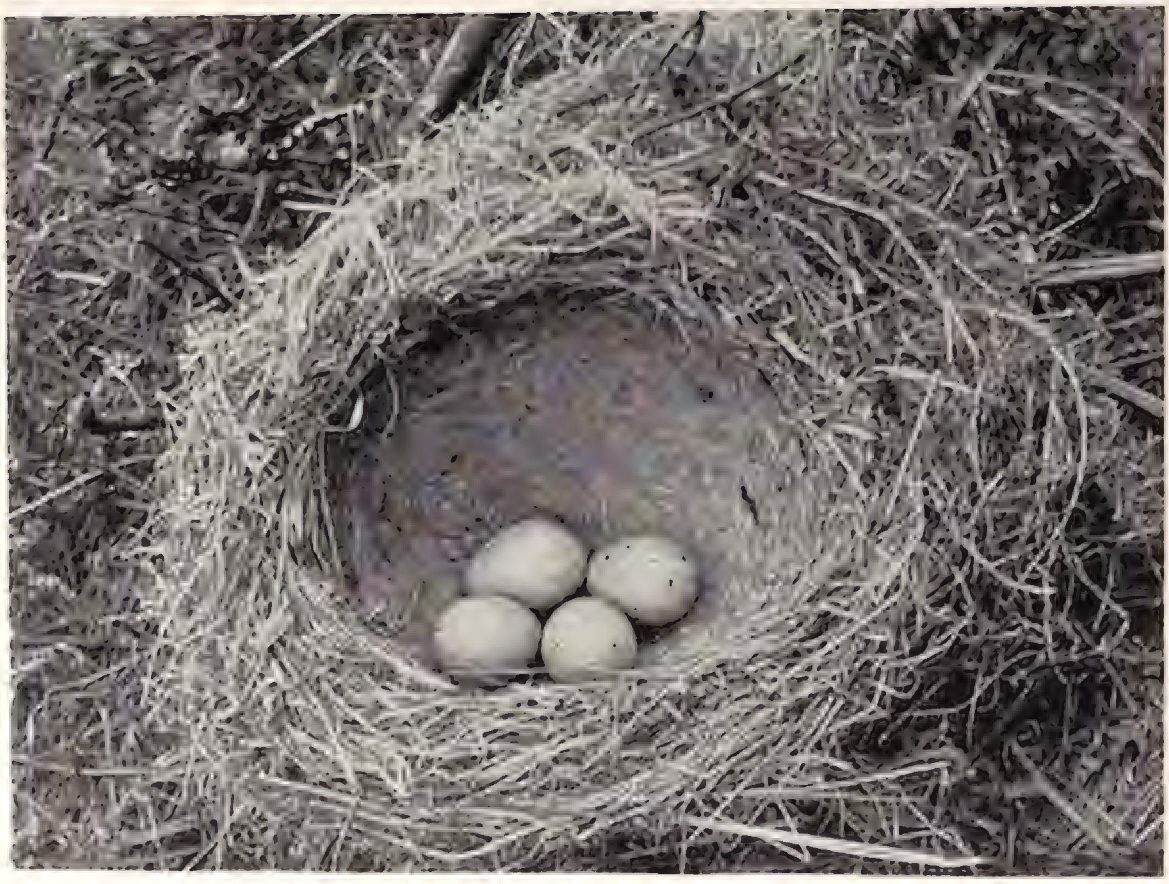


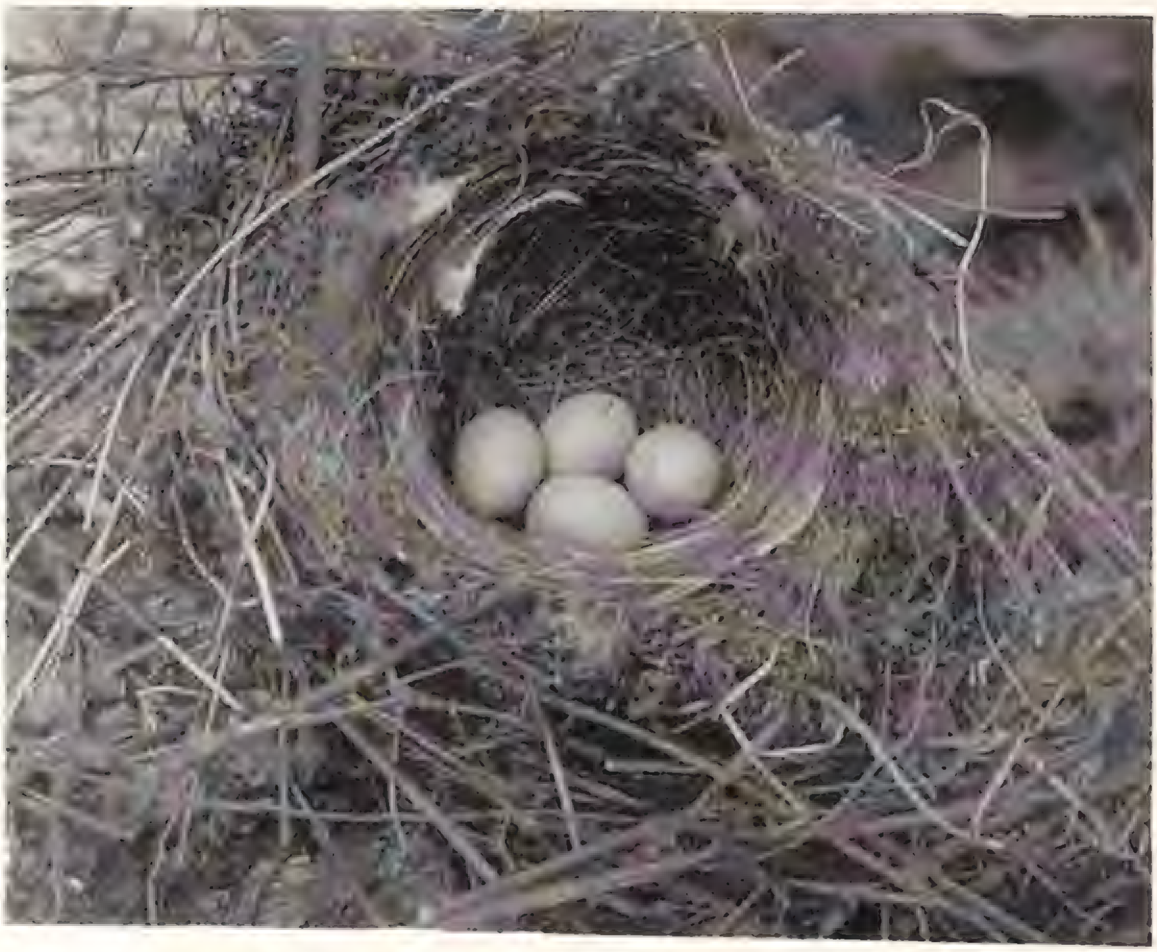
Fig. 28.—Pterichthys Milleri (Old Red Sandstone). (After Traquair.)

I fain wish I could communicate to the reader the feeling with which I contemplated my first-found specimen. It opened with a single blow of the hammer, and there, on a ground of light-coloured limestone, lay the effigy of a creature fashioned apparently out of jet, with a body covered with plates, two powerful looking arms articulated [jointed] at the shoulders, a head as entirely lost in the trunk as that of the ray or the sunfish, and a long angular tail. . . . Imagine the figure of a man rudely drawn in black on a grey ground; the head cut off by the shoulders; the arms spread at full, as in the attitude

PLATE 22

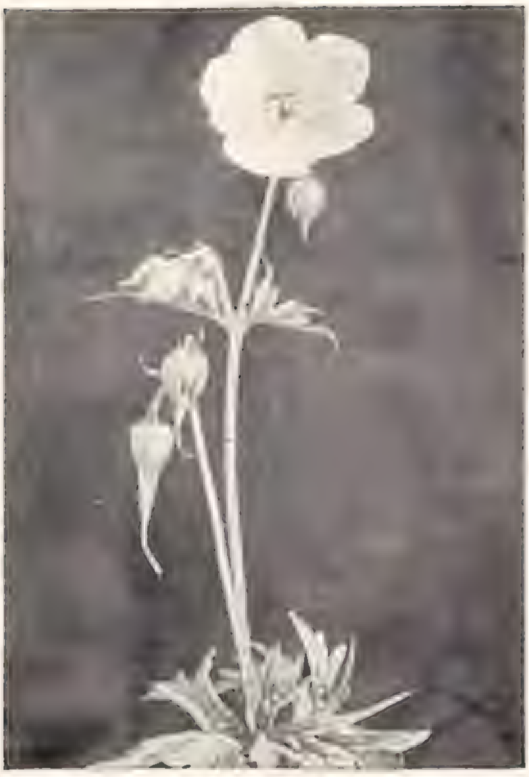


(*a*) Nest and Eggs of Song-Thrush. *P*. 162.

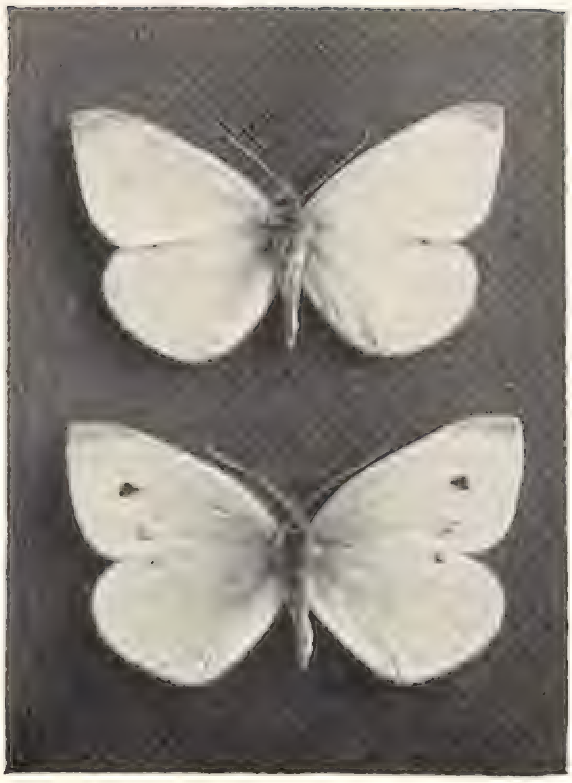


(*b*) Nest and Eggs of Hedge Accentor. *P*. 149.

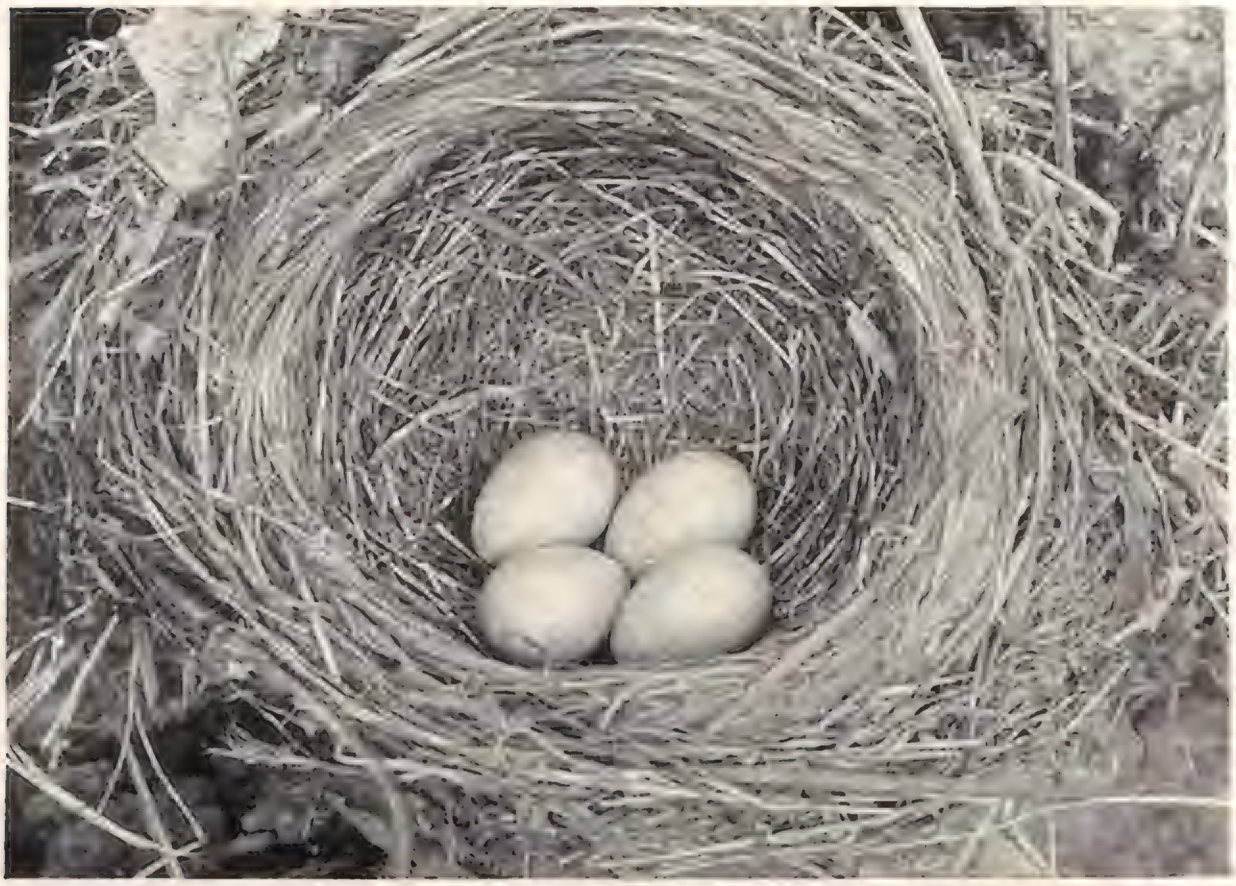
PLATE 23



(*a*) Meadow Crane's-bill. *P.* 185.



(*b*) Small White Butterfly (upper, male ; lower, female). *P.* 154.



(*c*) Nest and Eggs of Blackbird. *Pp.* 155, 162.

of swimming; the body rather long than otherwise, and narrowing from the chest downwards; one of the legs cut away at the hip-joint, and the other, as if to preserve the balance, placed directly under the centre of the figure, which it seems to support. Such, at a glance, is the appearance of the fossil. The body was of very considerable depth . . . the under part was flat; the upper rose towards the centre into a roof-like ridge, and both under and upper were covered with a strong armour of bony plates."

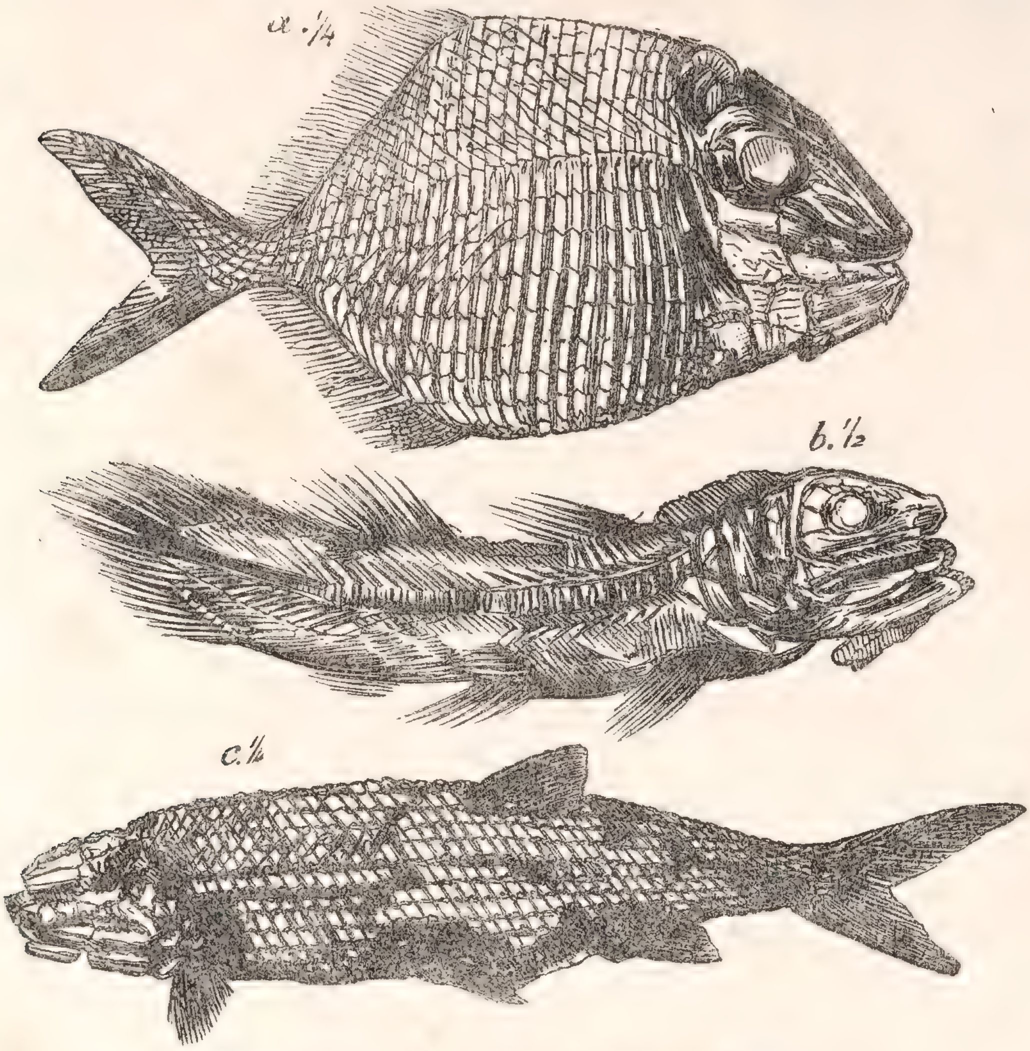


Fig. 29.—Permian Ganoid Fish.

a, *Platysomus striatus.*
b, *Cœlacanthus granulosus.*
c, *Palæoniscus comptus.*

Pterichthys belonged to the earliest known type of fishes, the Ganoids (Greek, *ganos* = brightness, *eidos* = appearance), which were exceedingly numerous in early geological times, but have few living representatives. The sturgeon is an existing species, and so also is the garpike, which is found in the American lakes. Modern ganoids live in fresh-water lakes and rivers, and it is conjectured that the ancient ganoids were fresh-water fish, but many of them must have visited the seas just as our salmon do. The ganoids were like armoured cruisers, being clothed with plates of bone and enamelled scales, by which they were fortified against the attacks of enemies. We build armour-plated battleships at great cost of money and labour ; Nature furnished those early fish with defensive armour " without money and without price." The fact that they were so well defended indicates their need of defence ; there must have been an abundance of ferocious creatures eager to prey upon them. The struggle for existence has been keen in all ages. The ganoid fishes evidently flourished in Palæozoic and Mesozoic times, but after the latter Era they seem to have waned. They were numerous in the Carboniferous Period, and

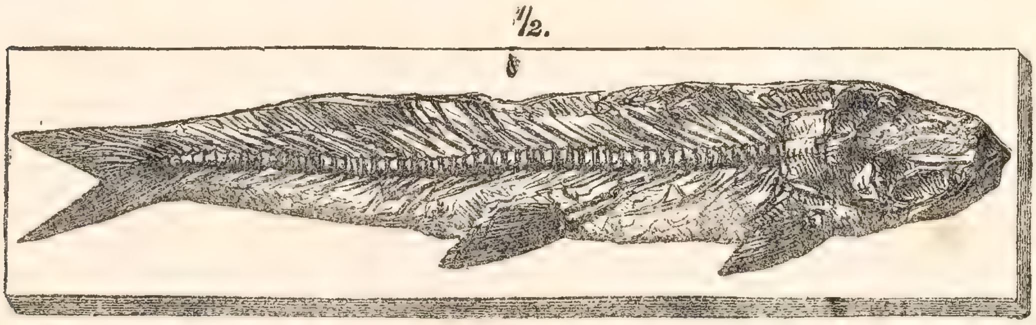


Fig. 30.—Jurassic Fish (Leptolepis macrophthalmus).
(From Oxford Clay.)

fossil remains of small ganoids are found in Jurassic strata. Modern scaled fish, like the roach, dace, carp, and perch, which you will have seen in fresh water, and others which live in the sea, are of fairly recent origin. You do not find them in rocks older than the Cretaceous. Sharks and rays, however, have a long pedigree; remains of their kind are found in Silurian deposits. These fish, as you know, have soft skeletons, and no bony plates to protect them, so there is no wonder that the only remains we generally find of them consist of spines and teeth. Even in the most ancient times the shark's chief defence must have been its fierce and aggressive nature.

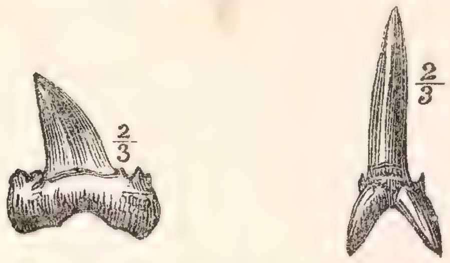


Fig. 31.—Teeth of Extinct Sharks from Eocene Strata.

I wonder if you have heard of the famous Australian Mud-fish named *Ceratodus?* It is found in the rivers of Queensland, and specimens may be seen in the London Zoological Gardens. Ceratodus is a genuine fish, and something more. Like ordinary fish it can breathe in water by means of gills, but unlike them it has an air-bladder which has become a lung. When the rivers are full of water it lives like other fish, but when the hot season arrives, and the rivers dry up, it makes a home in the mud, and breathes by its lung. A relation, or rather an ancestor, of this remarkable fish lived in

Devonian times, and has been christened *Dipterus.* Its fossil remains have been found in Old Red Sandstone rocks of Scotland and Russia. Ceratodus means "horn-tooth"; Dipterus is from the Greek *dipteros* = two-winged. Fossils of the true Ceratodus have been discovered in Triassic rocks. Dipterus differed from Ceratodus in having a triangular tail and bony scales.

If you can get to a museum you must inquire for the fossil fishes, and examine them carefully; you will find them most interesting. A look over the collection in the London Natural History Museum will be a revelation to you.

2. *Amphibians* (Greek, *amphi* = both, *bios* = life). —Cold-blooded animals capable of living both in water and on land. In water they breathe by gills, and on land or in air by lungs. Toads, newts, and frogs will be familiar examples. Fossil Amphibians first appear in Carboniferous strata, and in that Period the Amphibia seem to have been the most highly developed living creatures. They then had no big reptiles, nor lions and tigers to compete with them for the mastery of the world. The order of Carboniferous Amphibians is long extinct. They are called *Labyrinthodonts*—*i.e.*, labyrinth-toothed—because cross-sections of the teeth of most of them show mazelike patterns. The Labyrinthodonts must have been like modern newts and salamanders. Most of them could swim and walk; at least, the well-developed tails and legs which fossil remains exhibit seem to bear out such a conclusion. Some of them were wholly, and others partly, protected by a coat of mail made up of scales; their chests

were defended by three bony plates. They varied in size from an inch or two in length to about eight feet. One or two kinds managed to flourish without limbs. There were many species in Carboniferous times; new species are found in Permian strata, and the Triassic rocks yield remains of some of them, as well as their footprints. These creatures have, indeed, left "footprints in the sands of time" in the most literal fashion.

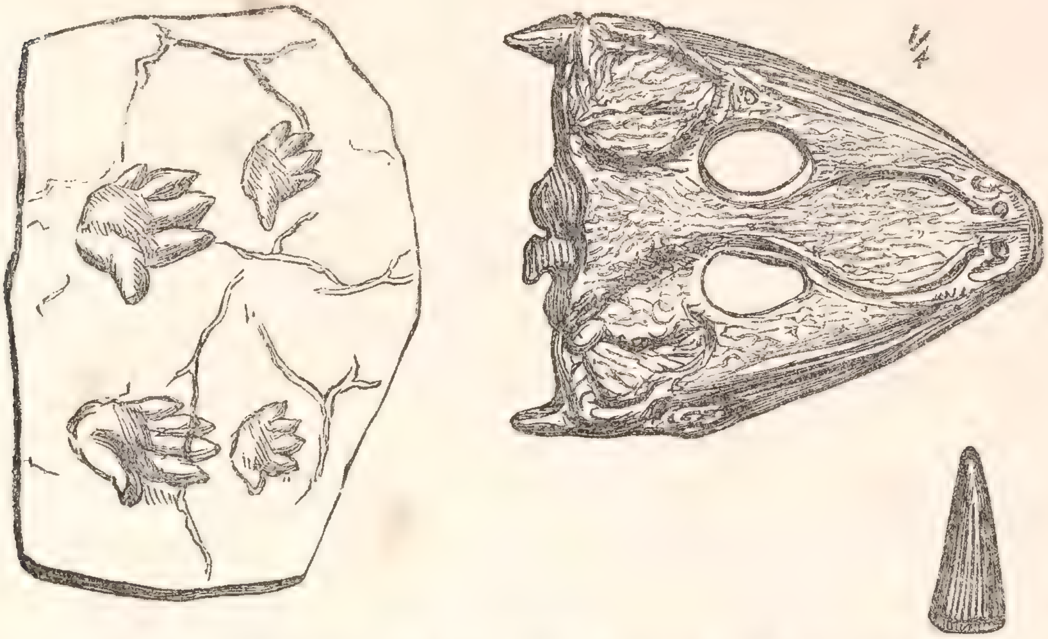


Fig. 32.—Footprints, Head and Tooth of Labyrinthodont (Labyrinthodon giganteum) from Triassic Rocks.

3. *Reptiles* (Latin, *repere* = to creep).—Cold-blooded animals which breathe entirely by lungs, and crawl on their bellies or by short legs. They have their bodies covered with scales or bony plates. Examples: Crocodiles, Snakes, Lizards, and Alligators. The Mesozoic Era is well called "The Age of Reptiles," for they flourished then as they have never done since. Remains of the earliest known reptiles have been found in Permian rocks, but the

reptiles of Triassic age are of more popular interest. It was in that Period that the long extinct order of *Deinosaurs* (Greek, *deinos* = terrible, and *sauros* = lizard) appeared. Had we lived in their age and met them on our rambles I have no doubt we should have thought the name that men have given them is fully justified. They must have presented a truly terrible appearance. They would be the monarchs of the earth at the time when they flourished. Most of them were of great size, resembling rhinoceroses and elephants in this respect. While they appeared in Triassic times, they attained greater development in the Jurassic Period. The *Iguanodon* (possessing teeth like those of the modern iguana, a land-lizard) was among the first discovered Deinosaurs, and when I tell you that it measured about twenty-four feet from the snout to the end of the tail, and that its head was poised about fourteen feet from the ground, you will realize that it was a beast of some size and power. It had a pair of long, powerful hind-legs and a pair of somewhat shorter and less sturdy front-legs. Its remains show that it would walk like a kangaroo ; footprints left by the animal and preserved in the strata prove this. A huge thigh-bone, bigger than that of the greatest elephant, of another Deinosaur has been found in the United States ; it belonged to the *Atlantosaurus*, which is estimated to have been nearly twice the size of the iguanodon. The *Megalosaurus* (Greek, *megas* = great, and *sauros* = lizard) was about twenty five feet long. It was carnivorous—that is to say, a flesh-eater—and it not unlikely preyed upon its weaker relatives, some of whom were vegetarians.

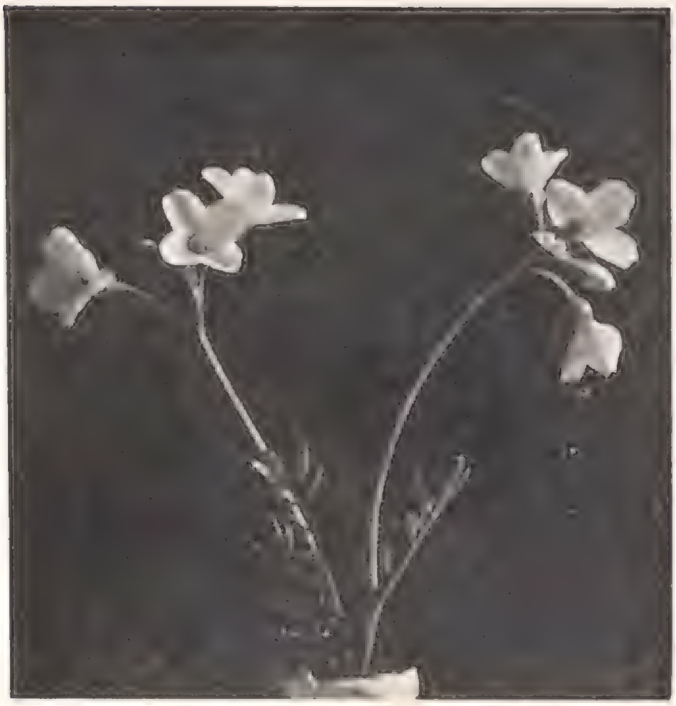
The Jurassic strata of North America have yielded remains of an even greater Deinosaur in the form of the *Brontosaurus.* It had big feet, which made impressions almost a square yard in size, long neck and tail, small head, and a short stout body. It is said to have been nearly sixty feet long, and to have weighed between twenty and thirty tons—not at all a nice creature to tread on one's toes! The *Stegosaurus* (Greek, *stegein* = to cover, and *sauros* = a lizard), or plated lizard, had a protection of great spines and plates along its back, some of the plates being nearly three feet across. The *Tyrannosaurus* (tyrant-lizard) was not so long as the Brontosaurus, but certainly he was more powerful. His feet were immense—four feet long by three feet wide. A contributor to *Knowledge* describes him in these terms: "We have every reason for congratulating ourselves that *Tyrannosaurus rex* is not our contemporary. He was practically a biped (two-footed animal), with an agile birdlike manner of progression, the immense feet possessing three enormous toes projecting forward, and one extending backward, all furnished with huge tearing claws. The head is much larger than that of the Brontosaur, and the great teeth are serrated (sawlike) and sharp-edged." It is said that Tyrannosaurus was the largest flesh-feeding animal of which we have any knowledge, and the fiercest monster of the Mesozoic Age.

You would certainly be delighted if you could find fossil remains of some of these Deinosaurs. I cannot promise you that you will do so, even if you search for the rest of your lives. I admit that I have not found any, but perhaps you may be more fortunate ; you never can tell. A wonderful " find " was made nearly thirty years ago in a coal-mine near Brussels ; in some soft rock were found remains of twenty-two monster Iguanodons. The restored skeletons of seven of these are now in the Brussels Museum, and a cast of one of them may be seen in the London Natural History Museum. See it if you can.

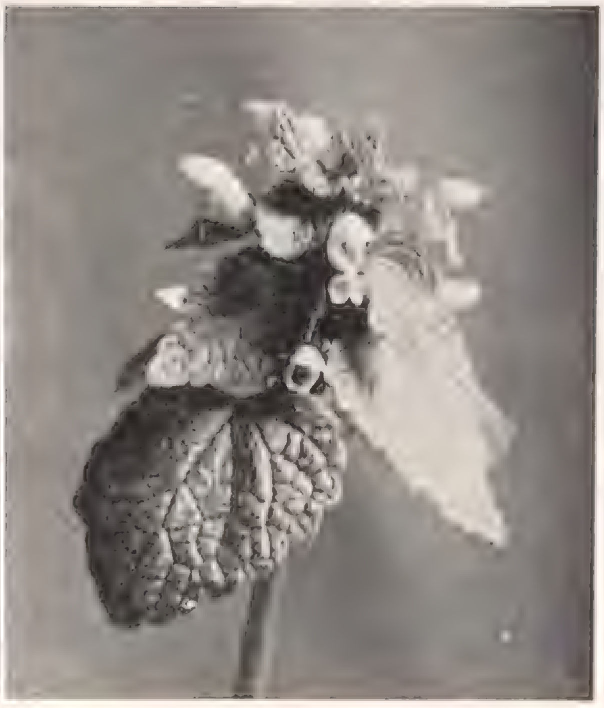
I must mention both the *Ichthyosaurus* (Greek, *ichthys* = a fish, and *sauros* = lizard) and the *Plesiosaurus* (Greek, *plēsios* = near to, and *sauros*). As its name implies, the Ichthyosaurus was a fish-lizard ; it sometimes attained a length of about forty feet, but there were smaller species. This animal had a thick body, a fishlike tail, and two pairs of paddles—a big pair to the front, and a smaller pair behind. It was largely a creature of the sea—perhaps of the shallow water—but it could crawl on land. It was fishlike in form. The *Plesiosaurus* was also a sea animal, which probably skirted the shores in search of prey. It had four paddles arranged like big oars. Its body was thick ; its neck was long, ending in a small head, armed with powerful jaws and pointed teeth. It was not nearly so fishlike as the last-mentioned animal. Many fossil relics of different species of Plesiosaurs have been found in the Jurassic Lias strata of the South of England.

The *Teleosaurus* (Greek, *teleos* = complete, and *sauros*) lived in Jurassic times ; its modern existing relative is the crocodile. The *Steneosaurus* was the Jurassic ancestor of the living alligator.

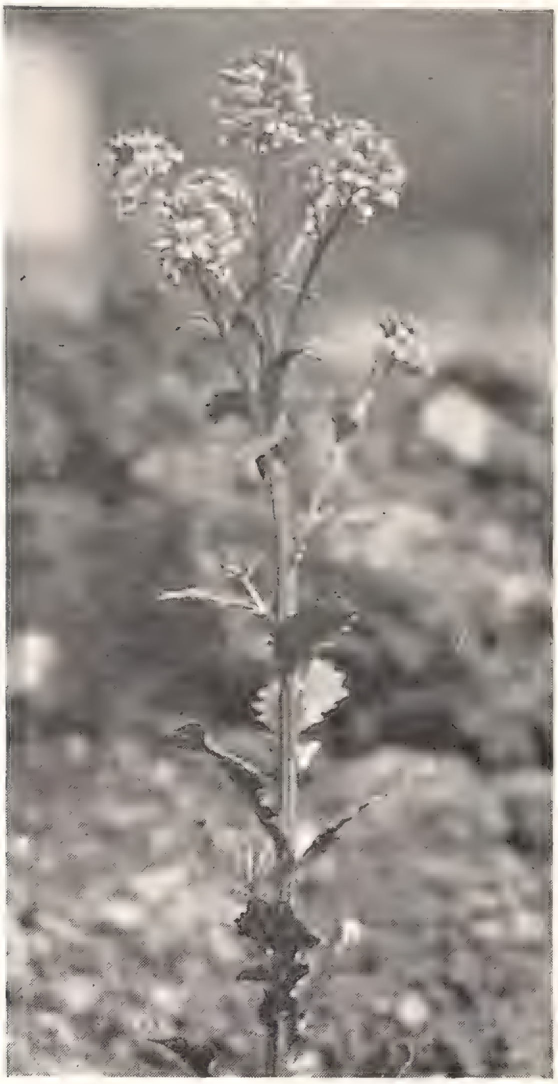
Perhaps one of the most curious orders of extinct



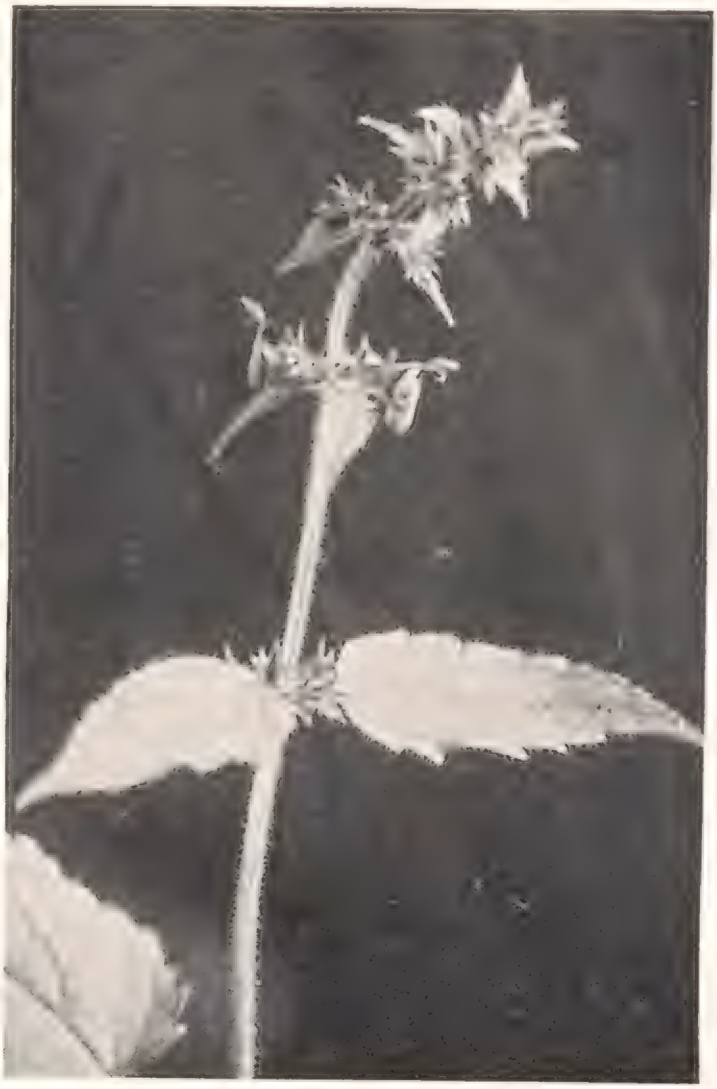
(*a*) Cuckoo Flower. *P.* 160.



(*b*) Red Dead-Nettle *P.* 151.

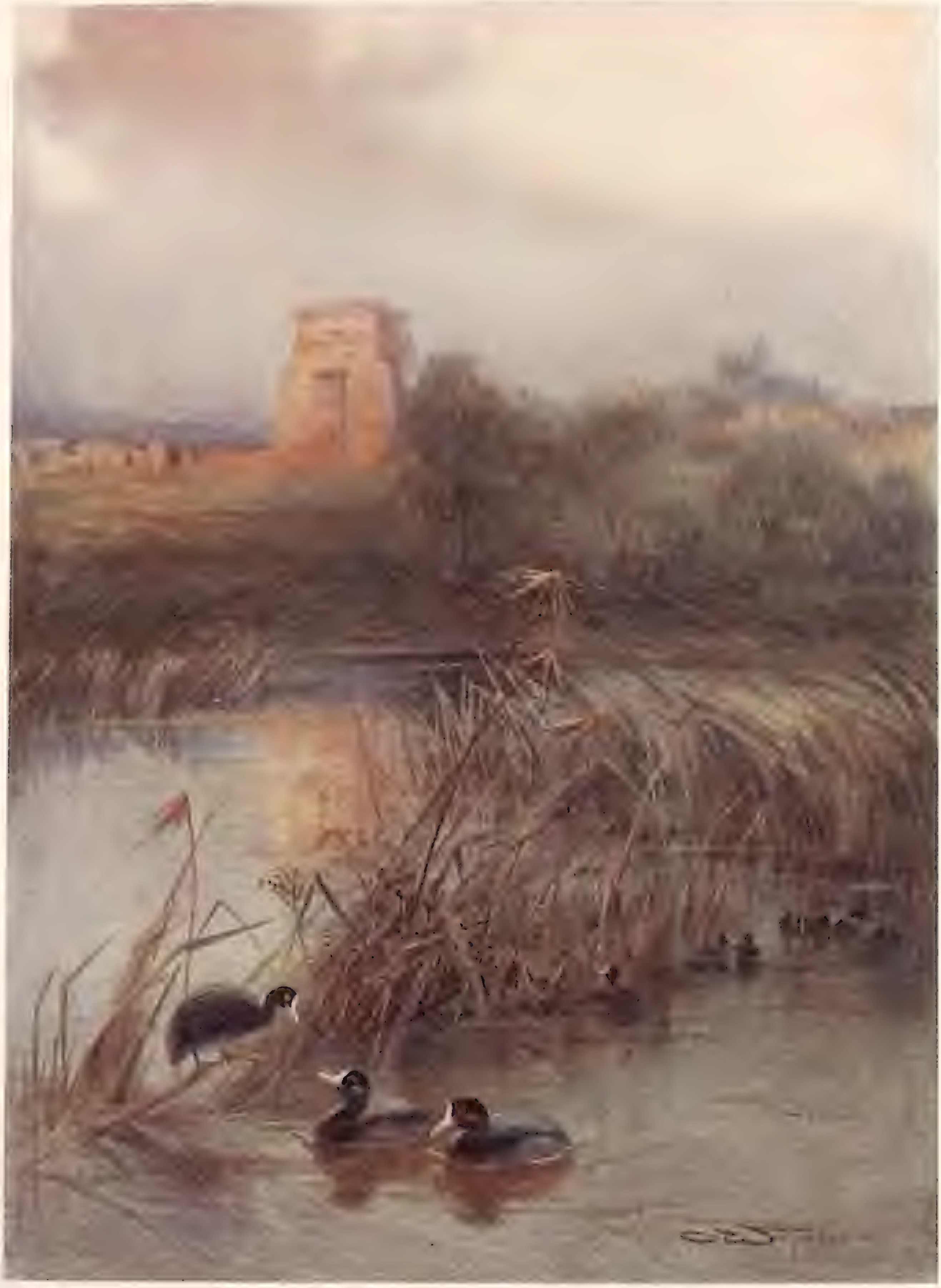


(*c*) Yellow Rocket. *P.* 184.



(*d*) Hedge Woundwort. *P.* 153.

PLATE 25



Coot. *See page* 159.

animals was that of the Flying Reptiles which go by the name of *Pterodactyles* (Greek, *pteron* = wing, and *dactylos* = finger). Several forms of these long extinct animals have been found in rocks of Jurassic age. They must have been most extraordinary and uncanny creatures. They were not birds, but genuine reptiles which had acquired the power of flight. Their wings had no feathers; they were membranes; each one stretched from the side of the body and the extremities of the hind-leg to a very long kind of finger or toe of the front-leg. When not in use the wings would probably be folded, like those of a bat; indeed, if you know what a bat's wing is like you will be able to form a very fair picture in your mind of the wing of a Pterodactyle. The restored skeleton of one of these flying reptiles (*Pteranodon*) shows a stretch of wing so extensive as eighteen feet, but they were not all so great. Some were quite small, hardly bigger than a bat or a pigeon. They must have borne a clumsy look, for their heads were quite out of proportion to their bodies. Their jaws were long and strong; some species possessed pointed teeth, others were toothless. The bones of these beasts were hollow like those of birds. In an age when reptile life abounded, and when there was a great amount of fighting done among them, you can see that the winged reptiles would have a great advantage in their power of flight. They would pursue prey and secure food

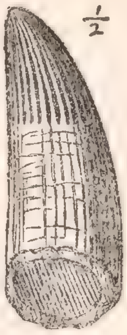


FIG. 33.—TOOTH OF A CROCODILE-LIKE REPTILE OF JURASSIC AGE.

which wingless reptiles could not hope to get, and they would have excellent means of escape when attacked. The competition for the means of life must have been exceedingly keen among the swarms

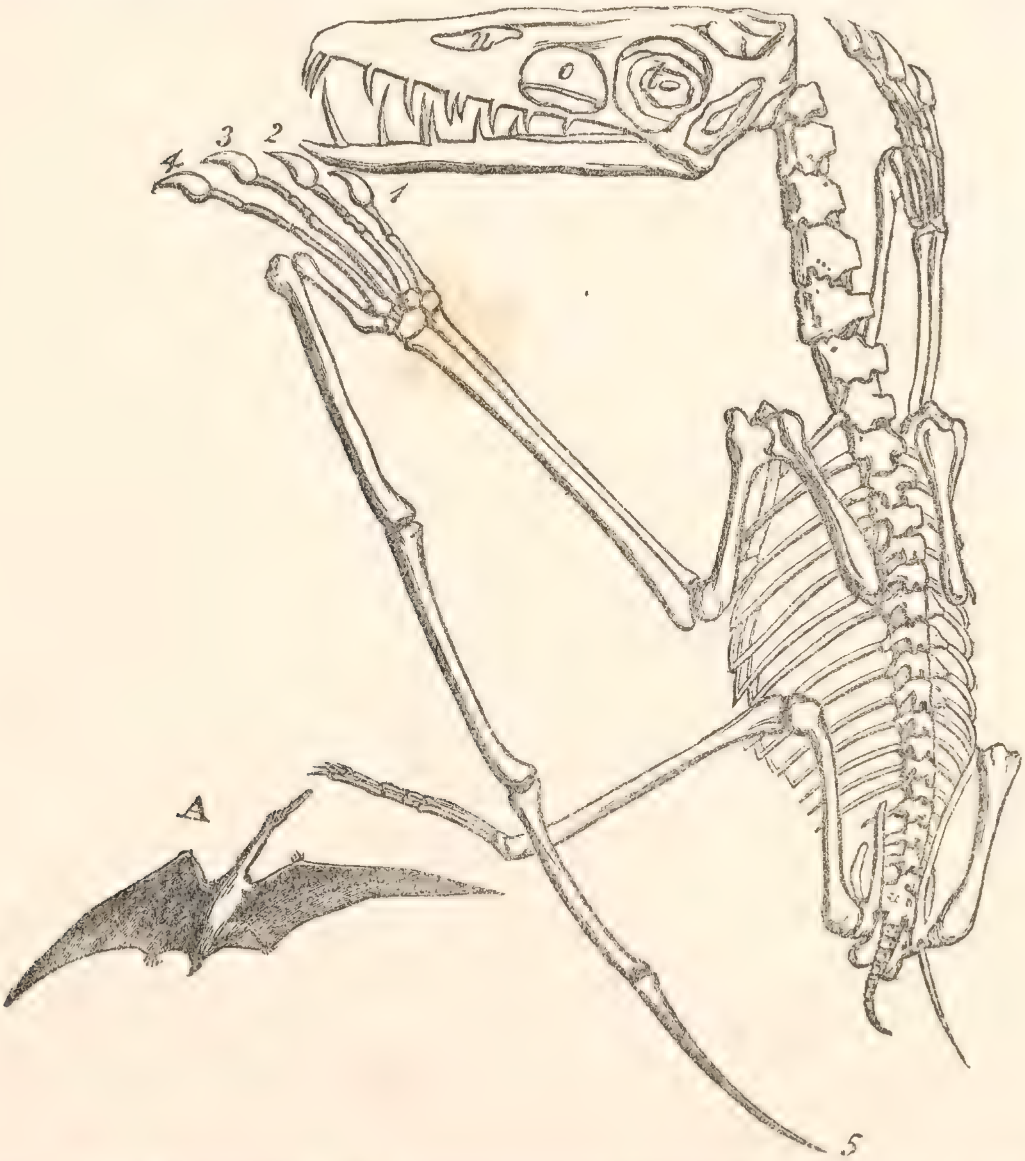


Fig. 34.—Skeleton of Pterodactyle from Jurassic Rocks.

A = appearance the animal would present when alive.

of reptiles of the Mesozoic Era. Reptilian forms of life became less numerous in Cretaceous times, and their dominion of the earth was even then doomed. The Mammals were destined to become the rulers, and they came into their kingdom in the Cainozoic Era.

4. *Birds.*—I do not think I need describe this great class of the Vertebrate Animals. You know a bird when you see one, but I am sure you would have some difficulty in giving exact reasons for a bird being a bird! Fossil remains of birds have been found, but in no great quantity. The discovery of the fossil *Archæopteryx* (Greek, *arche* = a beginning, and *pteryx* = a wing) in Bavaria a good many years ago aroused some popular interest, and with excellent reason. It was the remains in a Jurassic limestone of the earliest kind of bird of which we have any knowledge. The Archæopteryx was about the size of a rook, but it was not at all like that bird in appearance. It had no beak, and its head was more like that of a reptile than a bird's. Its jaws were toothed, and it had a peculiar lizard-like tail. Yet it was a genuine bird, and had plenty of feathers. Fossil remains of birds have been got out of the Cretaceous strata of Europe and North America, and more modern species have been occasionally turned out of Eocene deposits.

5. *Mammals* are so called because they suckle their young. They are lung-breathers and warm-blooded. MAN stands at the head of the Class. The Lion, Tiger, Elephant, Sheep, Pig, Rabbit, Ox, and Kangaroo, are well-known examples. The Class also includes Whales. Mammals began their career in quite a small way in Triassic times, but it was not until the Cainozoic Era that they began to abound in any great variety, and demonstrate their superiority to their predecessors. Eocene strata

yield remains of mammals akin to foxes and wolves, as well as of true opossums. Animals related to bats, hedgehogs, and squirrels lived in those times, and there were then some curious mammals which are now extinct. They were like elephants in respect of size, but they had the build of rhinoceroses; their remains show that they had six strong horns arranged on their heads—a pair on the forehead, one on each cheek, and a pair on the snout. They are called the *Deinocerata* (Greek, *deinos* = terrible, and *keras* = horn). Hornless deer existed in Eocene days. Mammal remains of now living species occur more and more frequently in the later Cainozoic deposits. Rhinoceroses, camels, bears, lions, stags, and wolves lived in Miocene times, and relics of antelopes, deer, giraffes, horses, gazelles, and oxen occur in the Pliocene strata. In the latter Age the Sabre-toothed Tiger played terrible havoc; luckily

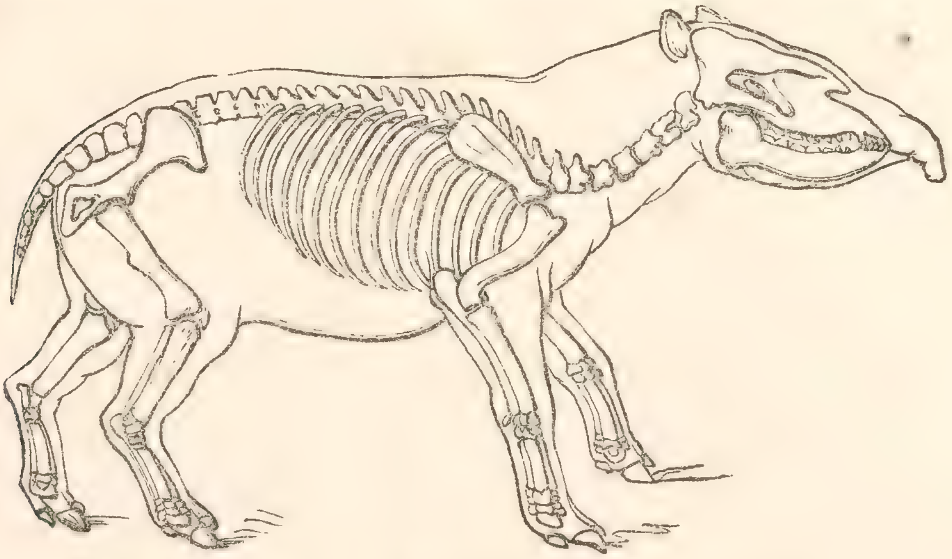


FIG. 35.—PALÆOTHERIUM (RESTORED).

An extinct mammal intermediate between the rhinoceros, the horse, and the tapir (Eocene).

it is now extinct. It was larger than the modern lion, and was furnished with canine teeth like curved daggers or sabres. These teeth, in a specimen found in South America, were twelve inches long. The *Megatherium* (Greek, *megas* = great, and *therion* = wild beast) was a Giant Sloth belonging to the Pleistocene days, and the *Mylodon*, also a big sloth, living at the same time, may possibly have survived in South America long after the advent of man. The Megatherium was built on a massive scale ; its length was some eighteen feet ; the Mylodon was not so large, being only eleven feet in length. In comparison with the extinct big sloths, those which live nowadays are quite small.

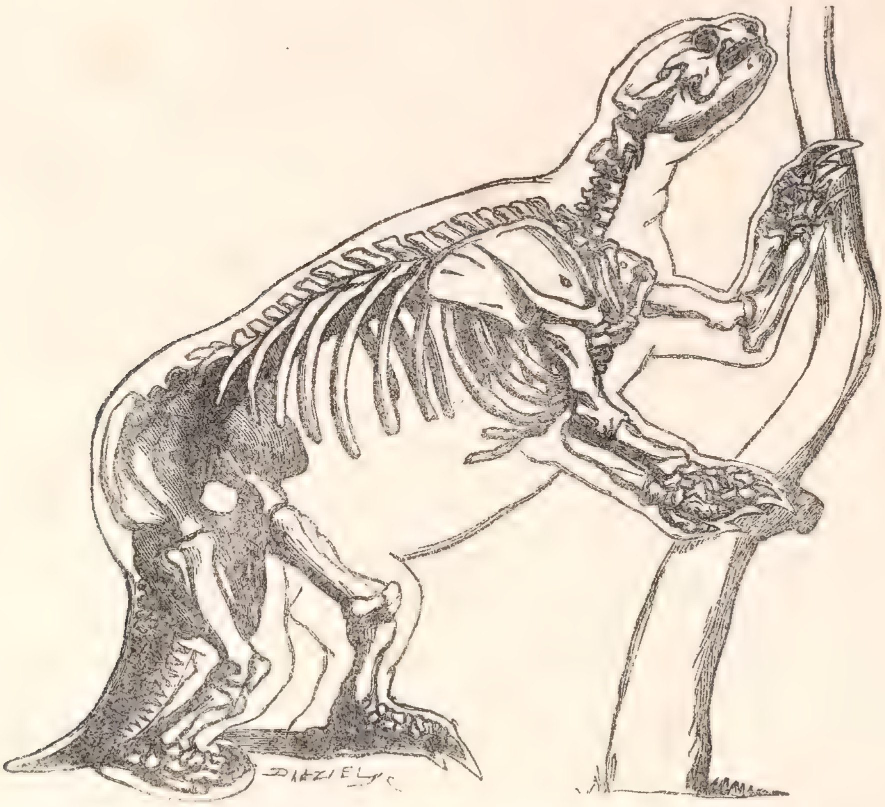


Fig. 36.—Mylodon robustus (Restored), from Pleistocene Deposits in South America.

In Miocene strata remains have been found of the *Mastodon* (Greek, *mastos* = nipple, and *odous* = tooth), which was a big kind of elephant usually having two pairs of tusks, one in each jaw; and also of the *Deinotherium* (Greek, *deinos* = terrible, and *therion* = beast), a big elephant-like animal having

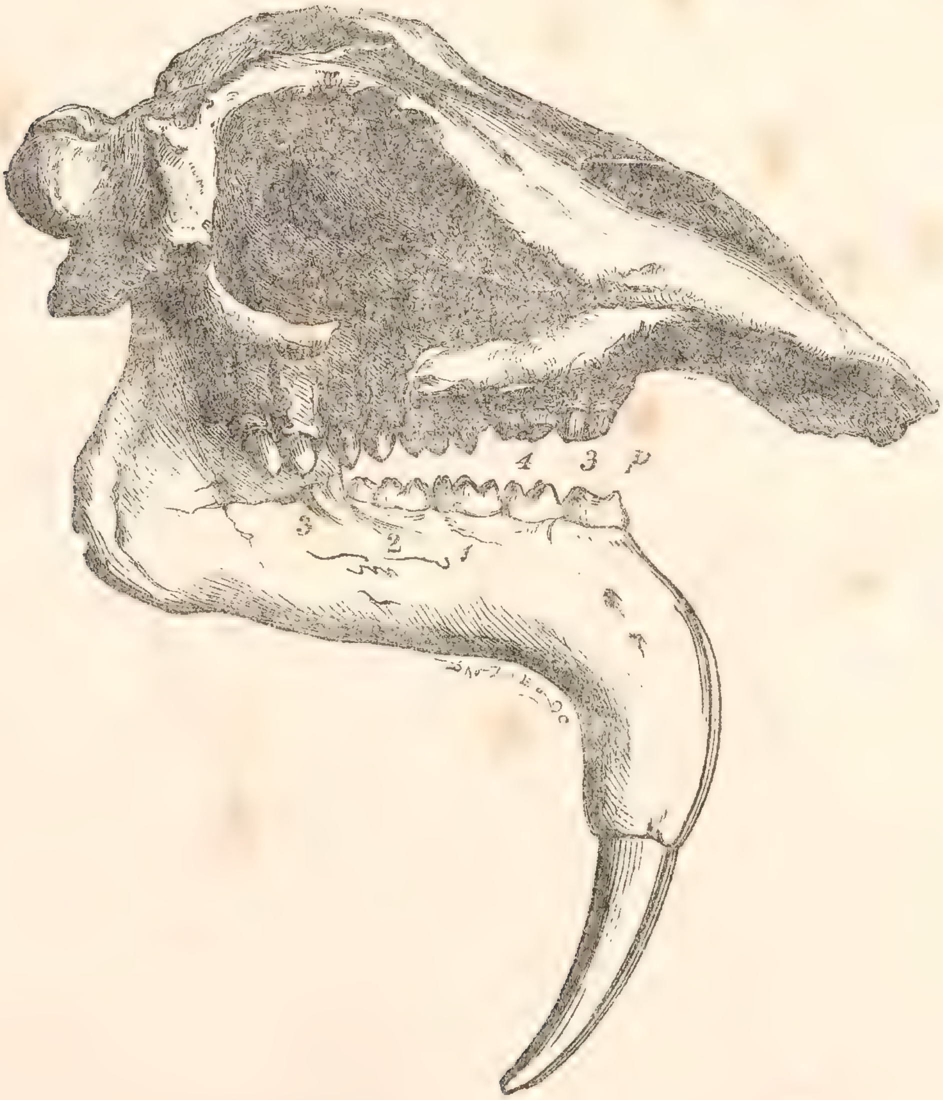


Fig. 37.—Skull of Deinotherium.

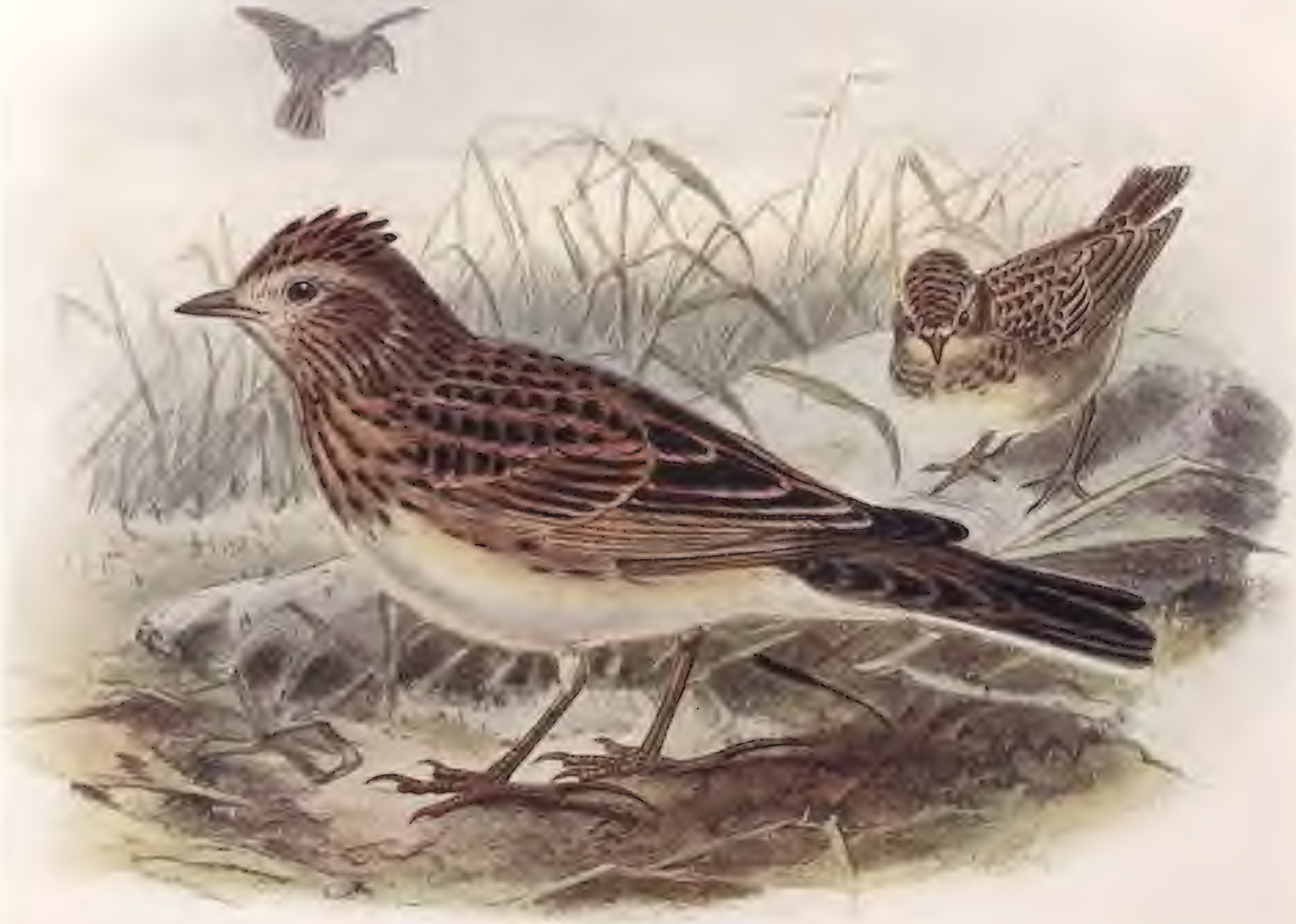
two large tusks in the lower jaw. These tusks were curved backwards, enabling their owner to use them in tearing up roots.

I shall conclude this imperfect sketch of the animal life of long ago by a reference to two extinct creatures which were in existence during the early days of primitive man. I refer to the *Woolly Rhinoceros* and the *Mammoth*, which flourished at the same time as the Irish deer and Cave-bear, both of which are also extinct. Both the Woolly Rhinoceros and the Mammoth had shaggy coats, enabling them to endure a cold climate. They roamed in quest of food all over Europe and across Britain, which in their day was still connected by land with the Continent. When towards the end of the Ice Age the ice gradually withdrew northwards, these animals followed the retreating ice, and travelled as far north as Northern Siberia, where Mammoths have been found beautifully preserved, flesh, wool and all, in blocks of ice. The scientific name of the Mammoth is *Elephas primigenius*, which means that it was an early kind of elephant ; it is said that it was a close relation of the existing Indian elephant. Doubtless primitive men had some very exciting times in hunting this huge and powerful beast. Mammoth remains have been found in Britain and various parts of Europe, and also in North America, Asia, and Africa.

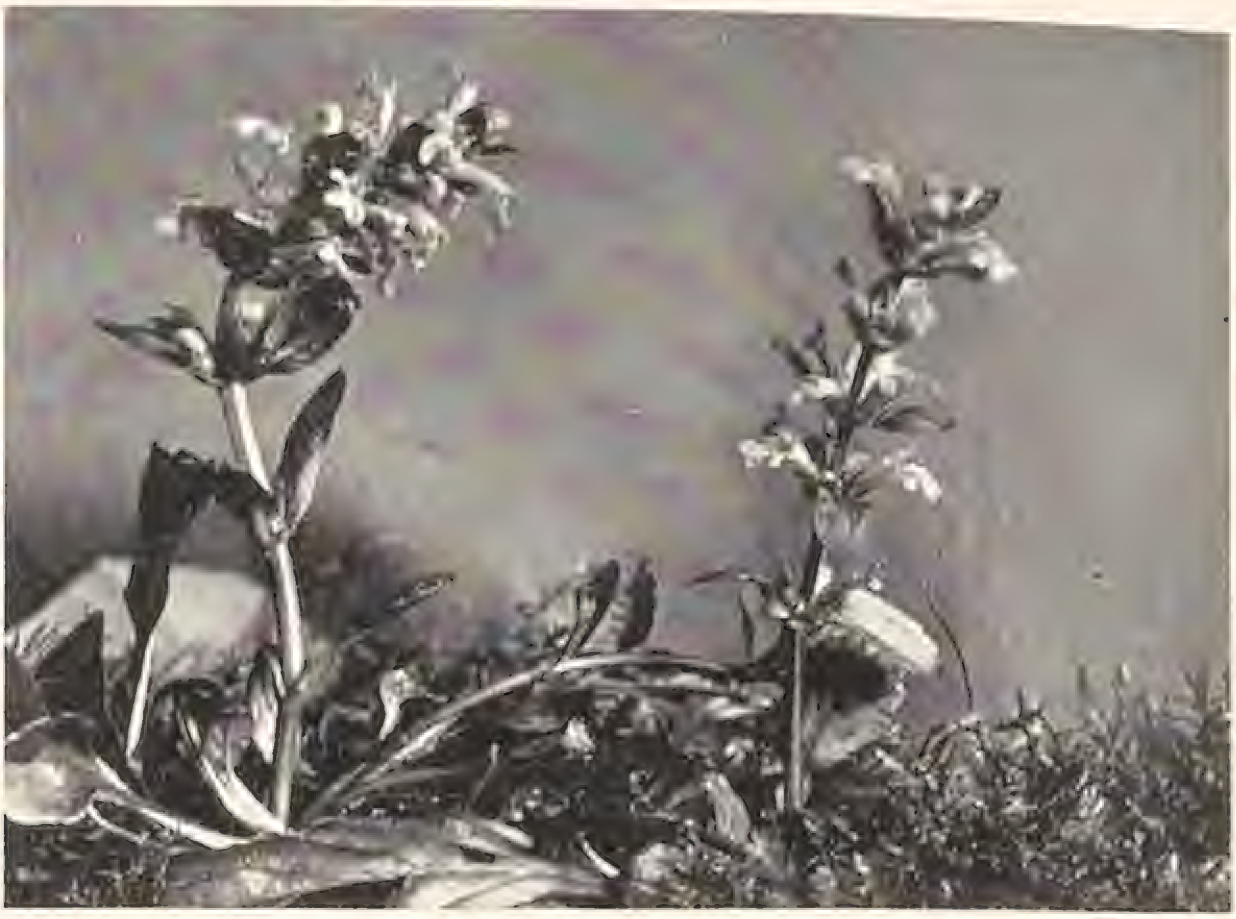
In following this little account of some fossil remains of animals, I hope you have noticed that some of the simplest and lowliest of creatures are represented in the oldest rocks, and that as we ascend the formations from the oldest to the most recent we find evidences of a gradual increase in the variety of animal life, as well as of more perfect and complicated life-forms. In ascending the formations we also ascend the scale of creation. In the older rocks we find fossils of Foraminifera, Radiolarians, Sponges, Graptolites, Corals, Starfish, Sea-urchins, Sea-lilies, Worms, Trilobites, and Molluscs. Then, a little higher in the scale, we discover Fish, to be followed, higher still, by Amphibians. The Reptiles are even more recent, not appearing till Permian times. Birds are found for the first time in Jurassic rocks, although they may be a little older. Then, lastly, we have the Mammals with their highest representative, Man, as the King and crown of creation. The most highly developed creatures were the last to appear ; creation has been a gradual unfolding and a wonderful growth—first the seed, then " the blade, the ear, and the full corn in the ear." I should like you to realize that Nature has always worked from the lowest to the highest, and still works on the same plan. One of the noblest uses of the study of fossils has been to make us understand the steps of creation, and know something about the ever-unfolding work of the Almighty. The earth's strata are like the leaves of a book on which the story of Creation is impressed. The first leaves are a veritable " Genesis "—book of beginnings—and the last leaves tell of the greatest results of Nature's working. But the story is not yet complete ; it is always being written. New leaves are even now being added from which the geologists of ages hence will be able to learn more of the story from records now being preserved.

Fossil remains of plants tell the same story as those of animals. You can find early plant forms in the older rocks and higher plant-life recorded in recent strata. The fossil records of plant-life are

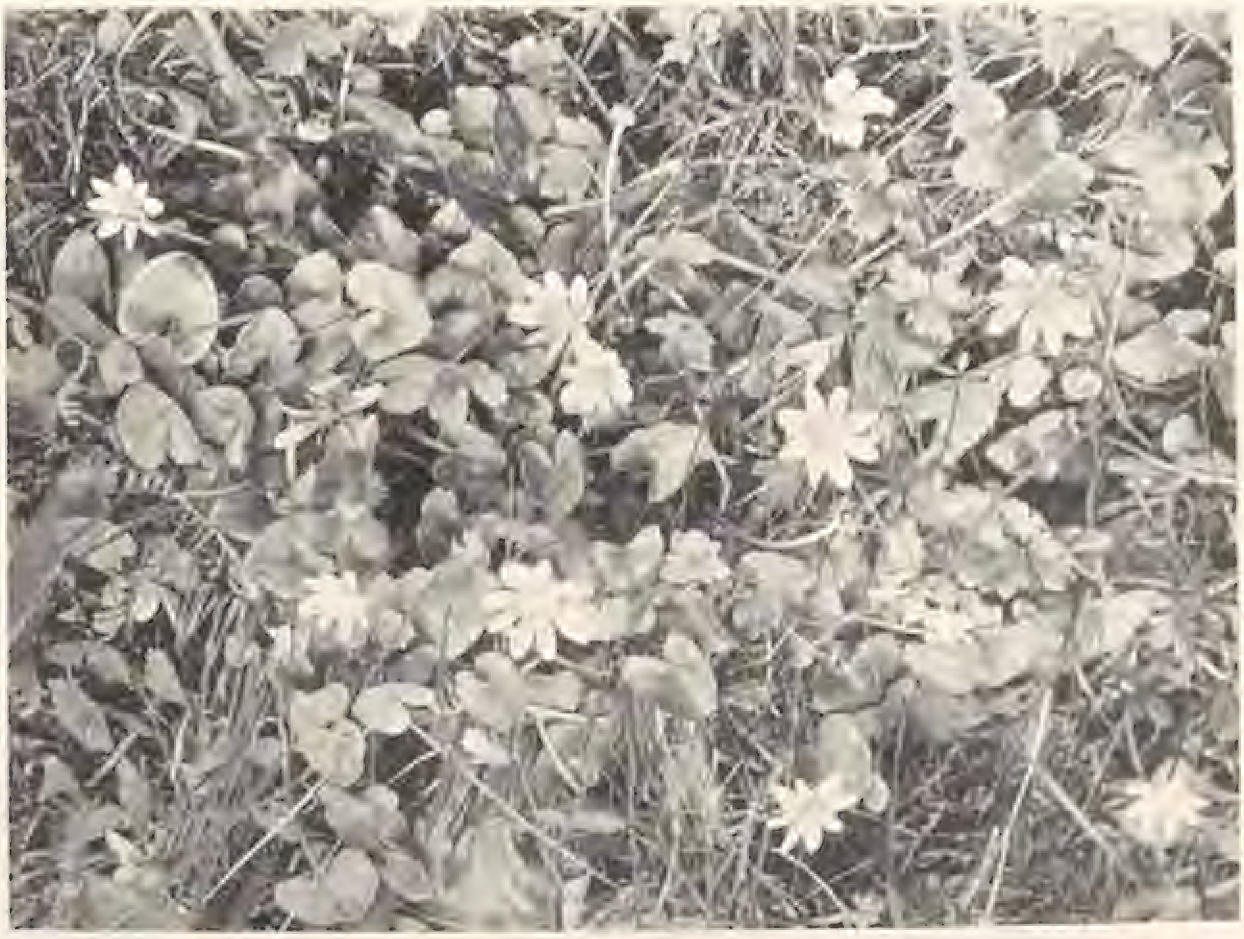
PLATE 26



Skylark. *See page* 173.



(*a*) Bugle. *P.* 154.



(*b*) Lesser Celandine *P.* 163.

very imperfect; when we think of the perishable nature of plants we could hardly expect them to be otherwise. But such records as have been found prove that plants have become more highly developed as the ages have advanced. First, there were seaweeds, fungi, mosses, and ferns, which are lowly forms of plants; these were followed by plants bearing naked seeds, such as the pines and cycads, and these were succeeded in later ages by palms, lilies, and the plants which bear beautiful and wonderful flowers.

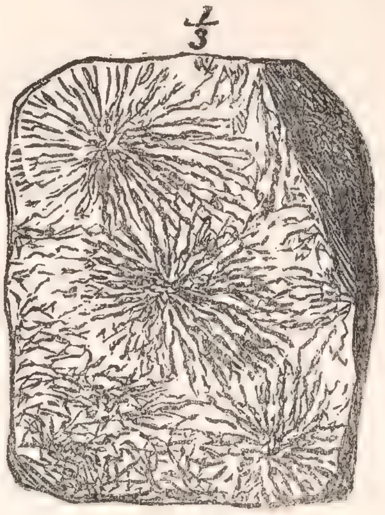


FIG. 38. — OLDHAMIA RADIATA.

There can be no doubt that seaweeds flourished in Cambrian times, and possibly earlier. A fossil has been found which has received the name *Oldhamia* (after an Irish geologist, Oldham). This is thought by some to have been a seaweed, although others think it may have been an animal. But if we are in doubt as to the real nature of *Oldhamia* we must conclude that an age which could produce shellfish and trilobites could also produce seaweeds and other lowly plants. The Silurian rocks have yielded undoubted remains of seaweeds, and it is in strata of this age we may find the earliest traces of land plants, in the form of *Lycopods*, or Club-mosses, and early ferns. Such fossil remains as are found of these plants occur in broken portions of stems and branches, which enable specialists to form some idea of the complete plants. Spores also occur, but you will need long practice in the practical study of fossil plants before you can make them out.

Plant remains occur in greater variety in the Devonian rocks. If you have access to the strata of this Period you must keep your eyes open for fossil seaweeds, ferns, club-mosses, horse-tails, as well as remnants of yews and pines.

But the fossil-plant collector finds a happy hunting-ground among the rocks of the Carboniferous Period. There he can find remains of the huge club-mosses, horse-tails and tree-ferns, which were evidently the principal features of the plant-life of those days. Existing club-mosses are dwarfs compared with their Carboniferous relations ; nowadays they never exceed three or four feet in height, and most of them are very much smaller ; but then they attained a height of fifty, and perhaps sixty, feet, and formed great forests. The *Lepidodendron* (Greek, *lepidotus* = scaly, and *dendron* = tree) was one of the commonest of those giant club-mosses. You can find traces of it in rubbish thrown out of coal-pits, and in quarries or cuttings in sandstones of Carboniferous age. The stems and branches which you find in fossil state are covered with lozenge-shaped scars, which mark the places from whence the stiff grasslike leaves had dropped. Or very often you find impressions of the plant on the rocks. I know of no more common or more interesting fossil plant. The *Calamites* (Latin, *calamus* = a reed) of the Carboniferous times grew to the size of forest trees. Of course, you know the modern horse-tail plant ; if you do not, get someone to point it out to you. Well, the Carboniferous Calamites were gigantic horse-tails. Imagine a horse-tail plant, say two feet high, such as you can see any day, magnified to the size of a tall poplar-tree,

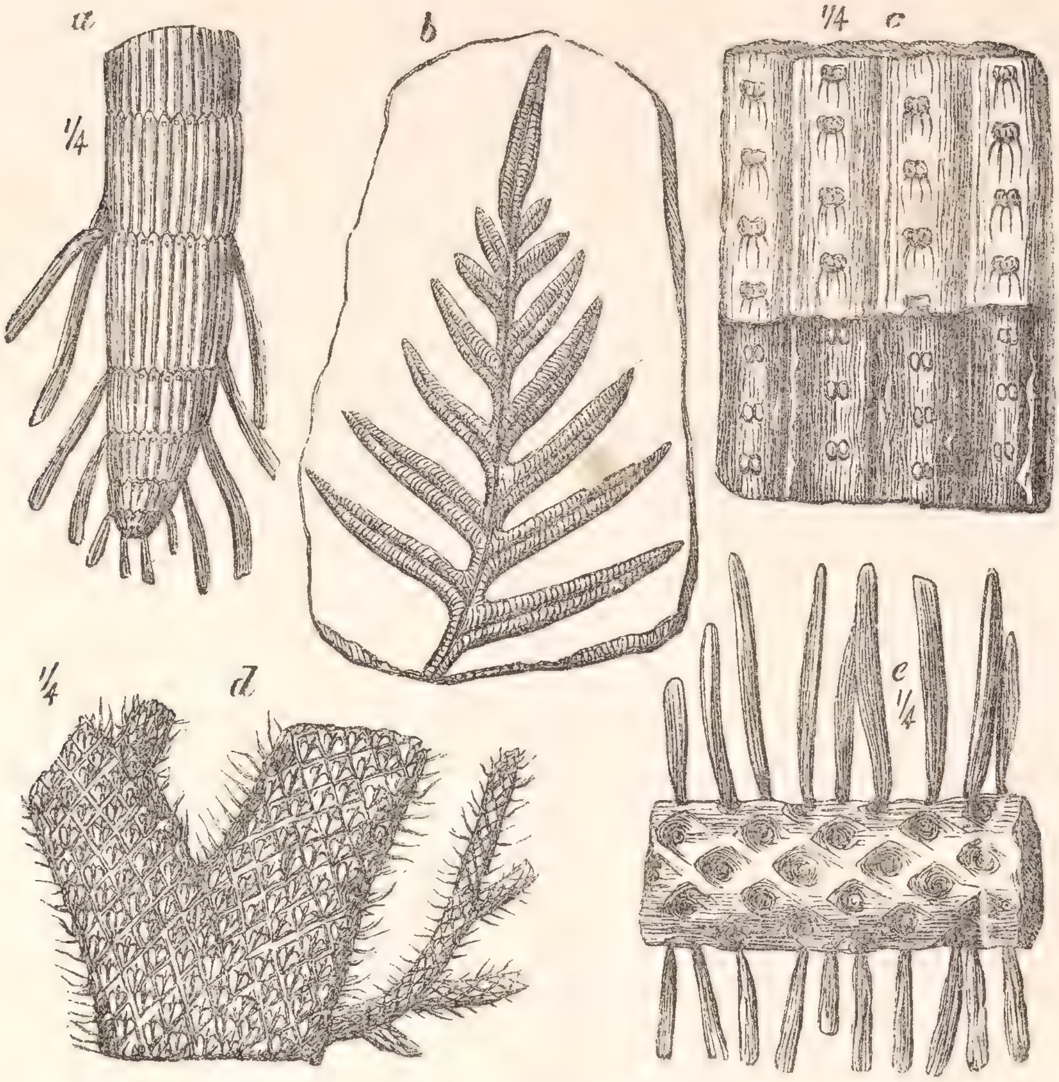


Fig. 39.—Fossil Remains of Carboniferous Plants.

a, Calamites cannæformis.
b, Alethopteris lonchitica (fern).
c, Sigillaria reniformis.
d, Lepidodendron elegans.
e, Stigmaria ficoides.

but retaining its horse-tail appearance, and you can form an idea of the Calamites of which fossil remains are found quite as commonly as those of the Lepidodendron.

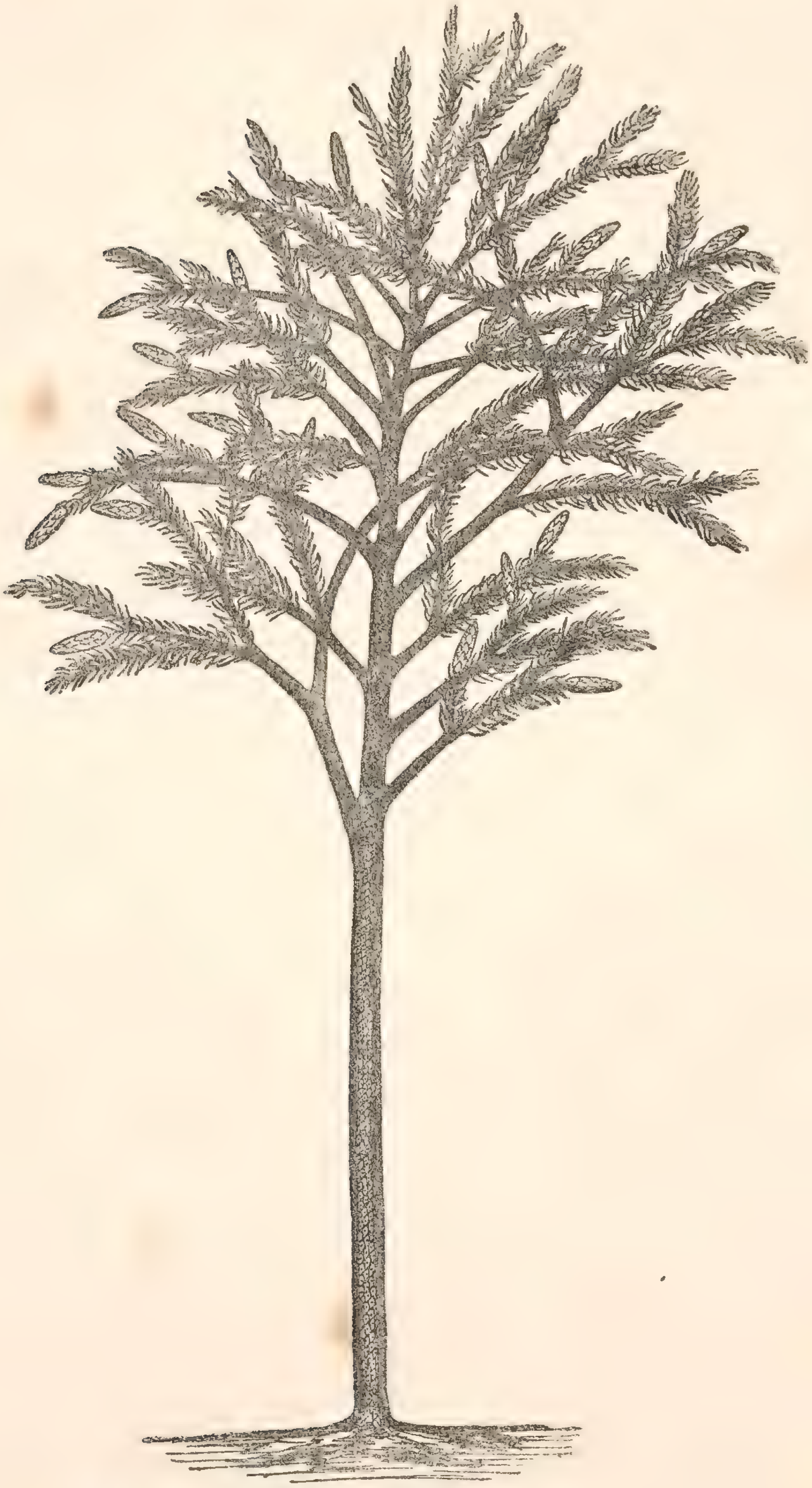


FIG. 40.—LEPIDODENDRON ELEGANS.

Restoration of tree, bearing cones. After Grand'Eury, modified.

Another plant-giant of the Carboniferous Period was the *Sigillaria* (Latin, *sigillum* = a seal), so called from the seal-like leaf-scars which the fossils show. The fossil stems of these plants are fluted, and each rib is marked with a row of leaf-scars. Some very large trunks have been discovered, one found at Saarbrücken, in Germany, being six feet in diameter at the base. The roots of Sigillaria are called *Stigmaria* (Greek, *stigma* = a puncture), and get their name from their punctured or pitted surfaces; they are commonly found in the fire-clay which generally lies under coal-seams. A specimen of Stigmaria showing a tree-stump over four feet in diameter, and roots thirty feet across, was found in a sandstone quarry at Clayton, Yorkshire; it may now be seen in Owens College Museum, Manchester (see Fig. 41). There are found in Carboniferous rocks

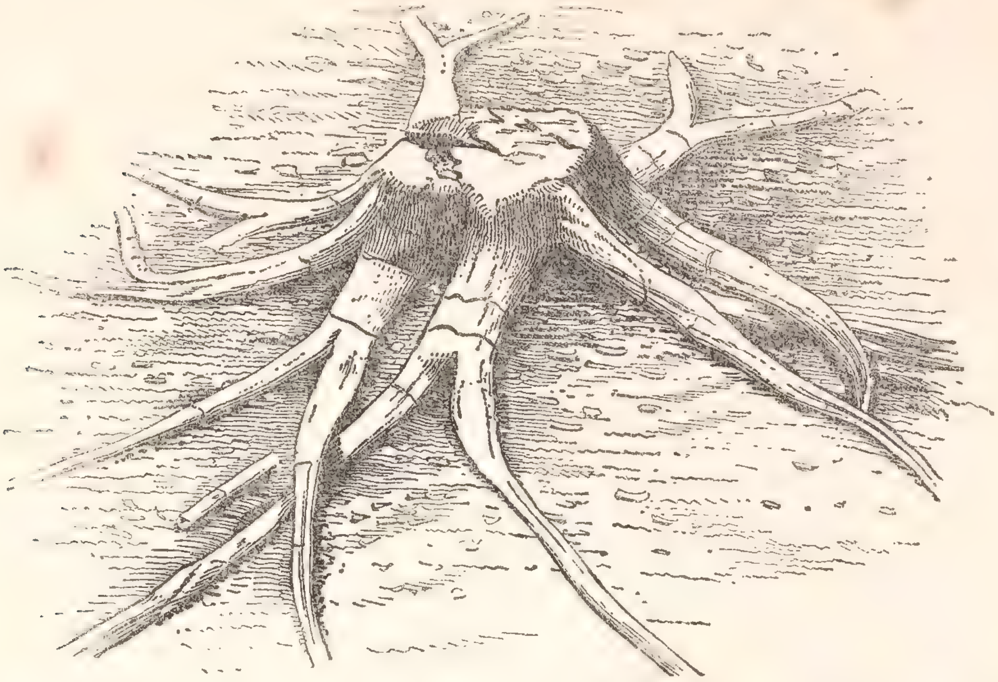


FIG. 41.—STUMP AND ROOTS OF STIGMARIA FICOIDES FROM THE COAL-MEASURES, CLAYTON, YORKSHIRE.

impressions of some ferns strangely like some modern species.

Generally speaking, the fossils of Permian plants resemble those of the Carboniferous Period. They include remains of club-mosses, horse-tails, and Sigillariæ, but the quantity and variety are less. Tree-ferns flourished in Permian times. Cone-bearing plants, like the fir, were common then, and it is in Permian rocks that are found the earliest traces of cycads (Greek, *kykas* = the doom-palm), which are fernlike plants having short branchless stems marked with scars of fallen leaves. The leaves are all clustered at the summit of the stem, and uncurl themselves like fern-fronds.

The coal-seams and shales of the Triassic Period yield relics of ferns, horse-tails, cone-bearing plants, and cycads, the last-mentioned showing an increase on the Carboniferous cycads, both as to quantity and species.

Cycads still flourished in Jurassic times, and very distant ancestors of our *Araucarias* ("Monkey-puzzles") existed in that period.

The Cretaceous rocks show an interesting development of plant-life. The lowest Cretaceous strata yield plant remains very similar to those found in Jurassic rocks; but higher beds of later deposition contain remains of vegetation strikingly like that of modern times. In addition to remains of palms, cycads, pines, and many ferns, we find abundant traces of familiar trees, such as poplars, oaks, walnuts, figs, beeches, buckthorns, and planes. And from Cretaceous times the vegetation became more and more modern, as the fossils contained in the succeeding strata abundantly testify.

I hope I have written just enough about fossils to make you want to know a lot more about them, to set you reading books about the ancient life of the earth, and above all to induce you to make a collection of such fossils as can be got in your district.

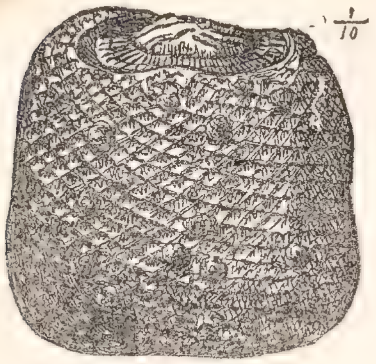


Fig. 42.—Fossil Stump of a Cycad (Cycodeoida microphylla) from Jurassic Deposits.

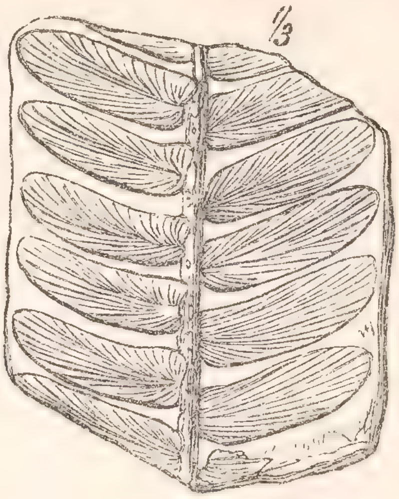


Fig. 43.—Fossil Remains of a Jurassic Fern (Otopteris obtusa) from Liassic Deposits.

Now, you must make your collection in a scientific way ; there must be no ignorant guesses, no slipshod work.

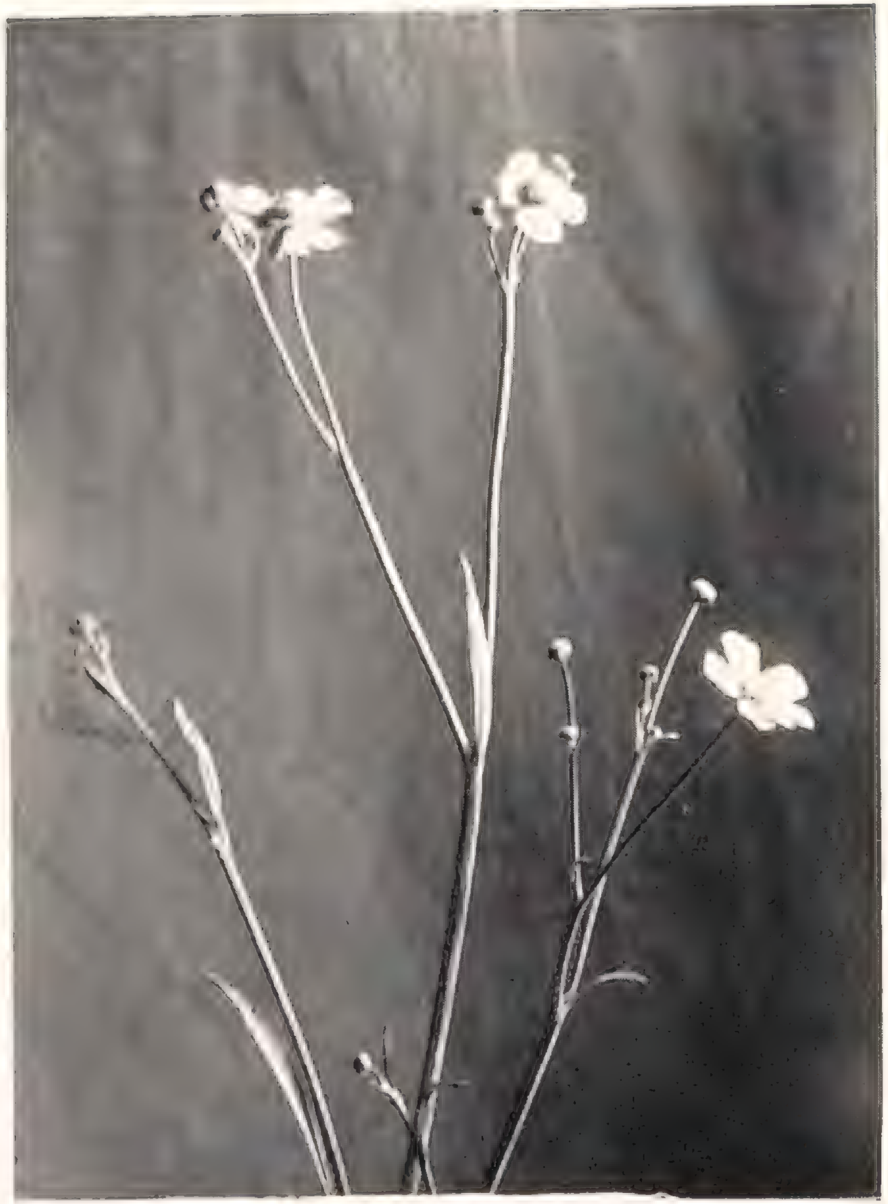
Just as you have been advised to collect specimens of rocks and minerals obtainable in your neighbourhoods, so you are counselled to begin your fossil collection within an area close at home. You should set out to collect specimens of fossil plants and animals that illustrate the geology of your district.

The fossils when collected must be classified, labelled, and arranged. You can place them in home-made trays, each tray to contain fossils of the same species ; don't mix several species in one tray. Then the trays can be arranged in glass-topped boxes—those that may be had from drapers do very well—and the arrangement must be in genera, or families. The families must be ordered according to Classes, and so on. Each specimen must have a label something like this :

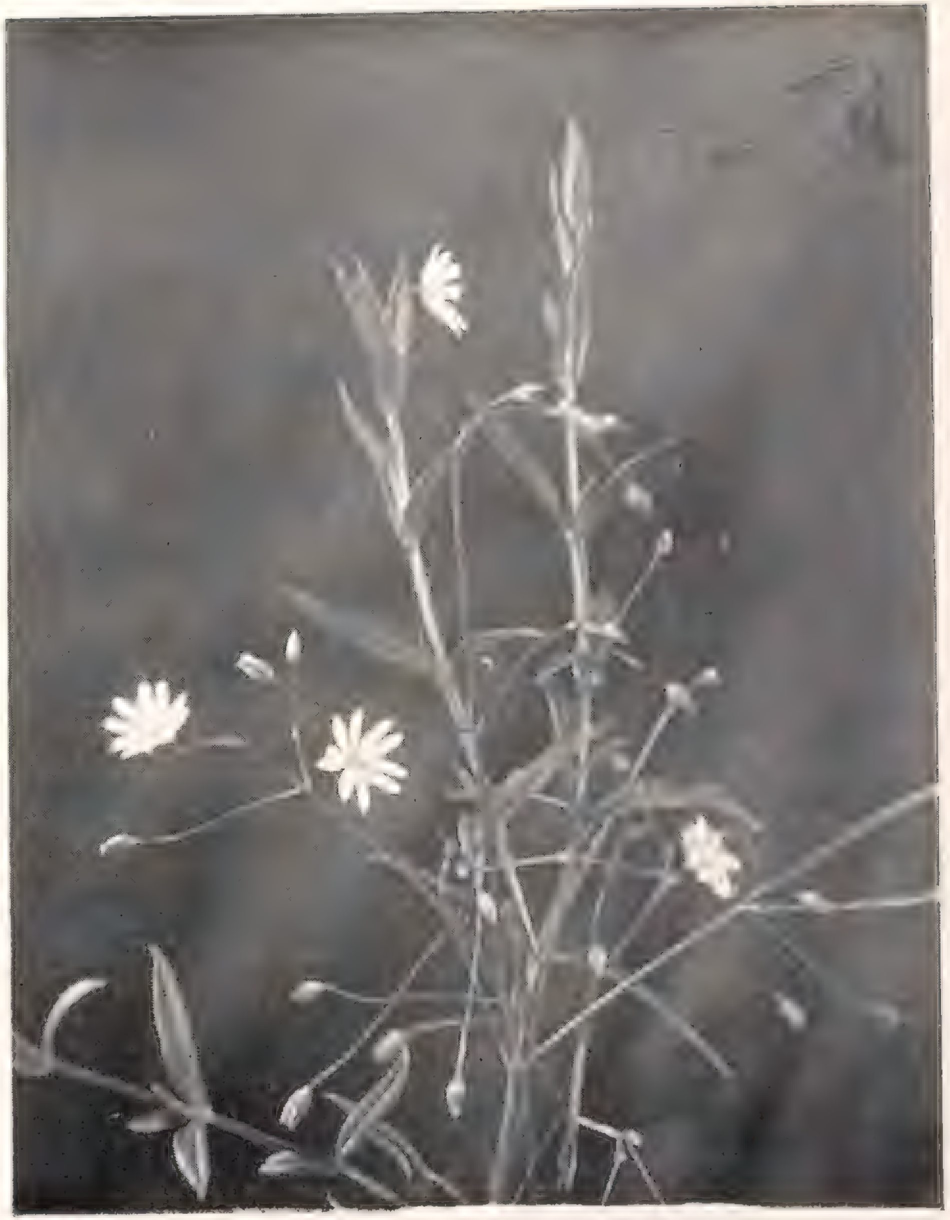
GENUS : *Pterichthys.*
SPECIES : *Milleri.*
FORMATION : *Old Red Sandstone.*
LOCALITY : *Cromarty.*

If you like, you can add the English name of the specimen, if it has one, or the derivation of the scientific name. You should also make notes of any peculiar circumstances connected with the finding of your specimens. As your collection grows, you may find it useful to keep separate boxes for the various Classes of your fossils. Thus you can have a separate box for the *Mollusca,* another for the *Arthropoda,* and so on. Again, your fossils, or the boxes containing them, should be arranged according to Eras and Periods. Cambrian fossils come first, then Ordovician, Silurian, Devonian, Carboniferous, and Permian. The boxes containing fossils of these Periods should have the general label : "Fossils of the Palæozoic Era."

You will have heard of the old receipt for hare soup, which commenced "First catch the hare."

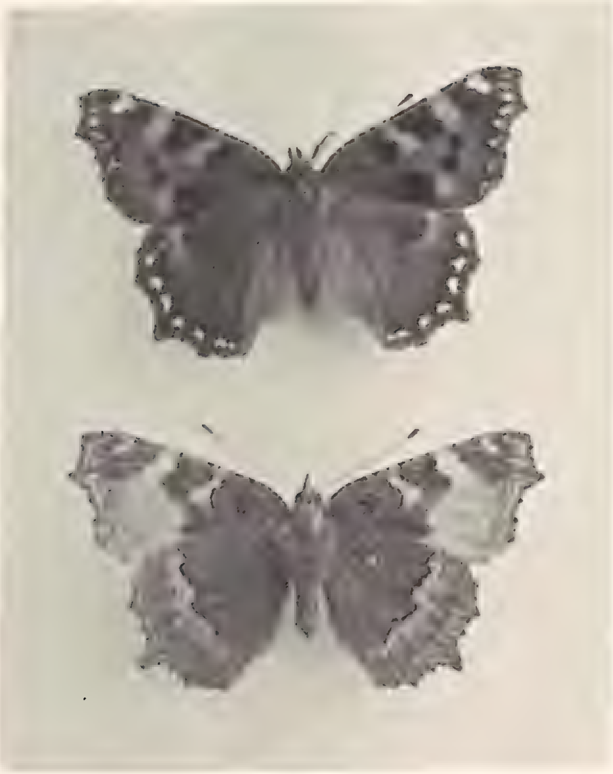


(*a*) Lesser Spearwort. *P.* 160.

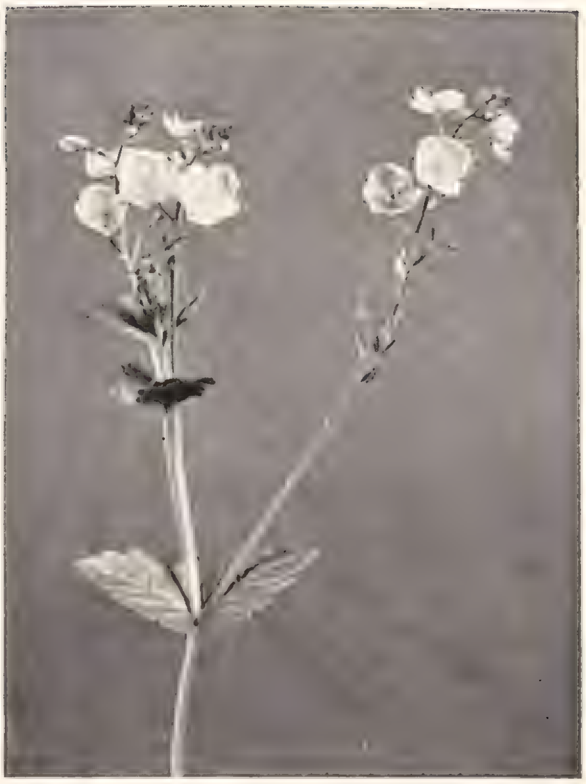


(*b*) Lesser Stitchwort. *P.* 164.

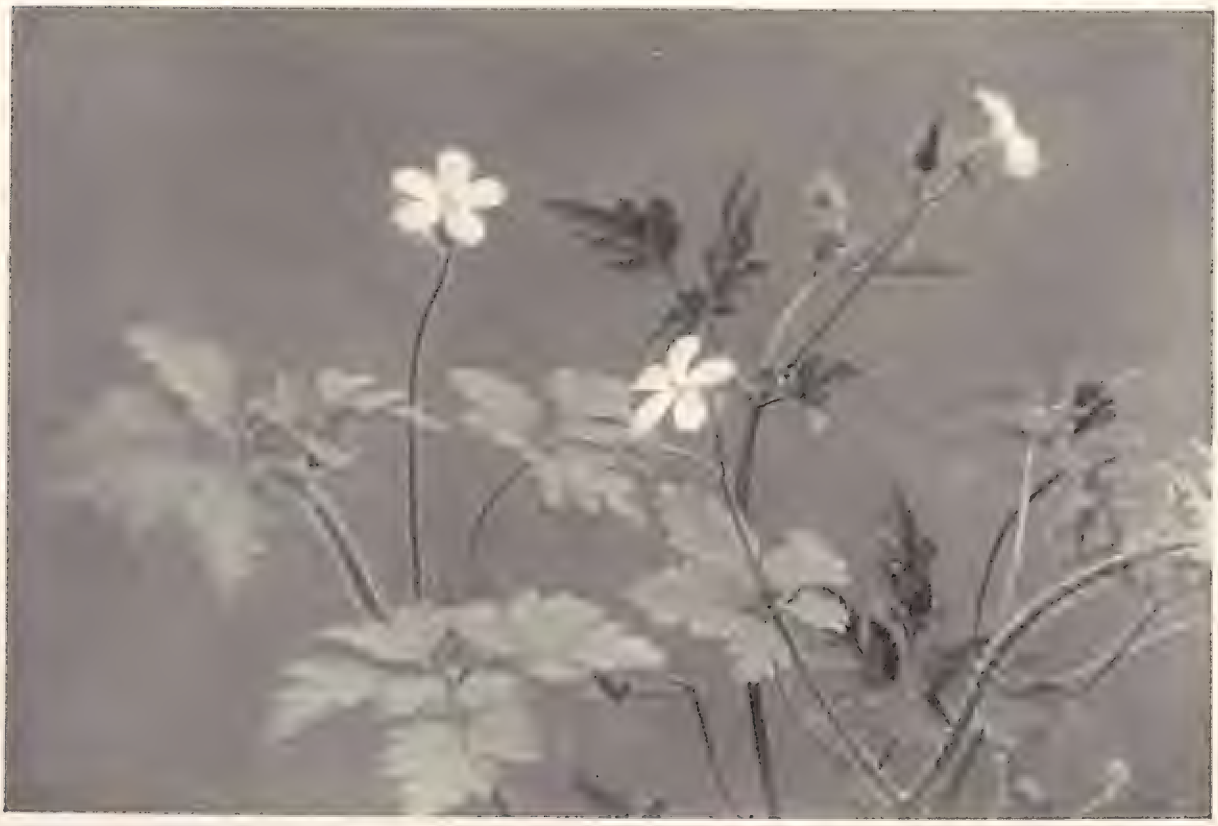
PLATE 29



(*a*) Small Tortoiseshell Butterfly (upper and under sides). *P.* 166.



(*b*) Germander Speedwell. *P.* 123.



(*c*) Herb-Robert.

As to the fossil collection and its arrangement, I ought to have begun with the advice "First get your fossils." I warn you they are not got without determination, effort, patience, and common sense. When you find fossils they often prove a little disappointing ; you do not always get good specimens, and there is often great difficulty in getting to know exactly what they are. Your district may not yield many fossils, but it may happen that it has some which are not common elsewhere. In the formation of your home museum you should aim first and foremost at having specimens of local things—things which illustrate the Natural History of the district as it was in the past, and is in the present. The geology of your locality will most likely have reference to but one Period—say, the Cretaceous, and the strata may belong to but one horizon or formation of that period—say, the *Wealden*, which is so well shown in the Weald of Sussex. Your local collection will then be confined to the rocks and fossils of the Weald. You will have a special opportunity for studying the fossils of the Wealden deposits ; take care to know them thoroughly.

The geological maps issued by the Government Geological Survey Authorities will prove of great value to you in your researches. They may usually be consulted in Museums and Free Libraries. From them you can learn the geological features of your locality, and the Periods which your rocks represent. When you come to name your fossils you will have some difficulties to overcome. Don't name any one of them until you are sure you are right. In this work you will have to consult books and local experts. You are sure to find someone who will gladly help you.

Of course, you won't spend day after day in searching for fossils in igneous rocks! Spend your efforts among sandstones, limestones, chalk, shales, clays, and gravels. Sometimes you will find among gravels and conglomerates fossils that have been washed out of clays and other rocks belonging to a different Period from that of the rocks you are examining. These are called "derived" fossils; don't be misled by them into wrong conclusions respecting their age.

Your eyes will gradually become practised in the art of detecting fossils, and you will learn the knack of getting them out of rocks without damaging them. A mason's chisel will help you in the latter business, and you must not forget your hammer.

I advise you to make friends with quarrymen. They often find fossils and lay them aside.

When you have got on with your collection, and see the interesting results of your work, I am sure you will find the gathering of fossils so delightful that you will not be content with a merely local collection; you will wish to secure specimens from other localities, and to get a collection which represents the life of all geological Periods. Holidays from home will be utilized in getting fossils which cannot be got in your own district, but even if you are not able to travel far away from home you can exchange specimens with other collectors. They say that "birds of a feather flock together," and I know from my own experience that when a person gets enthusiastic about a hobby or a study he soon finds others who have similar interests. Sometimes you may see in the columns of scientific and natural history journals advertisements of collectors who are willing to arrange exchanges.

I advise you to cultivate the art of sketching, and to make sketches of geological strata, as well as drawings of fossils. You will find that the very act of sketching makes you notice little details that might easily be overlooked. And you can make a very interesting collection of sketches and drawings which will prove useful to yourselves and others.

Personally, I never set out on a geological excursion without a photographic camera, and I have managed to collect a great number of photographs illustrating the geological features of the different places I have explored. If you possess cameras, take them with you on all your excursions. I do not favour hand-cameras for Nature-work; you cannot hold them steady long enough for the exposures that are usually needed. For geological photography nothing beats a stand camera; at least, that is the conclusion I have come to after many years' experience. If you can get a room to yourselves in which to form your museum, you can add to its interest by decorating the walls with enlarged photographs of fossils and rocks. If you want to interest your friends, why not make some lantern-slides, and give them an exhibition and a nice little talk? In trying to teach others you will improve yourselves.

Surely you cannot fail to enjoy geology and (awful word !) palæontology. It is a glorious thing to ramble about the country with an object in view, and always in the expectation of making a new discovery. As students of rocks and fossils you will have inducements to go out of doors and inhale the wholesome breezes ; you will find health, recreation, and knowledge. Even if you have no companions with you you will find "sermons in stones," and the rocks will tell you their story. Alone, you will not be lonely, and the hours will fly by all too quickly.

I began my Nature-study when I was very young, and it has never failed to provide me with delight. Often the business of life has held me in densely populated cities, and compelled me to breathe the polluted air of manufacturing towns. I know, too, the joy of the city and the pleasures of culture, art, and intellectual friendships, but I have never lost taste for the open country, nor the satisfaction of a lonely excursion. Along with me you will feel the longing of the poet :

"Oh, for a breath of the moorland,
A glimpse of the mountain grey ;
For the thyme and the fragrant myrtle,
That scent the wanderer's way !"

May you often find yourselves in such a place as the poet Crabbe describes :

"It is a lonely place, and at the side
Rises a mountain in rugged pride ;
And in that rock are shapes of shells, and forms
Of creatures in old worlds, and nameless worms ;
Whole generations lived and died, ere man,
A worm of other class, to crawl began."

BOOKS TO READ OR CONSULT.

All the books noted at the end of Chapter II. will help you in the study of fossils, with the exception of "The Story of Lost England." You will also find much valuable information in the following:

Extinct Monsters and Creatures of Other Days. Rev. H. N. Hutchinson. Chapman and Hall. 10s. 6d.

Extinct Animals. Sir E. Ray Lankester. Constable. 3s. 6d.

Fossils. I. W. Williams. Swan Sonnenschein and Co., Limited. 1s.

The Romance of Modern Geology. E. S. Grew. Seeley and Co. 5s.

Studies in Fossil Botany. Scott. A. and C. Black. 10s. 6d.

CHAPTER V

A TALK ABOUT BOTANY

THE poet wrote of a certain individual:

> "A primrose by the river's brim,
> Or by the cottage door,
> A yellow primrose was to him,
> And it was nothing more."

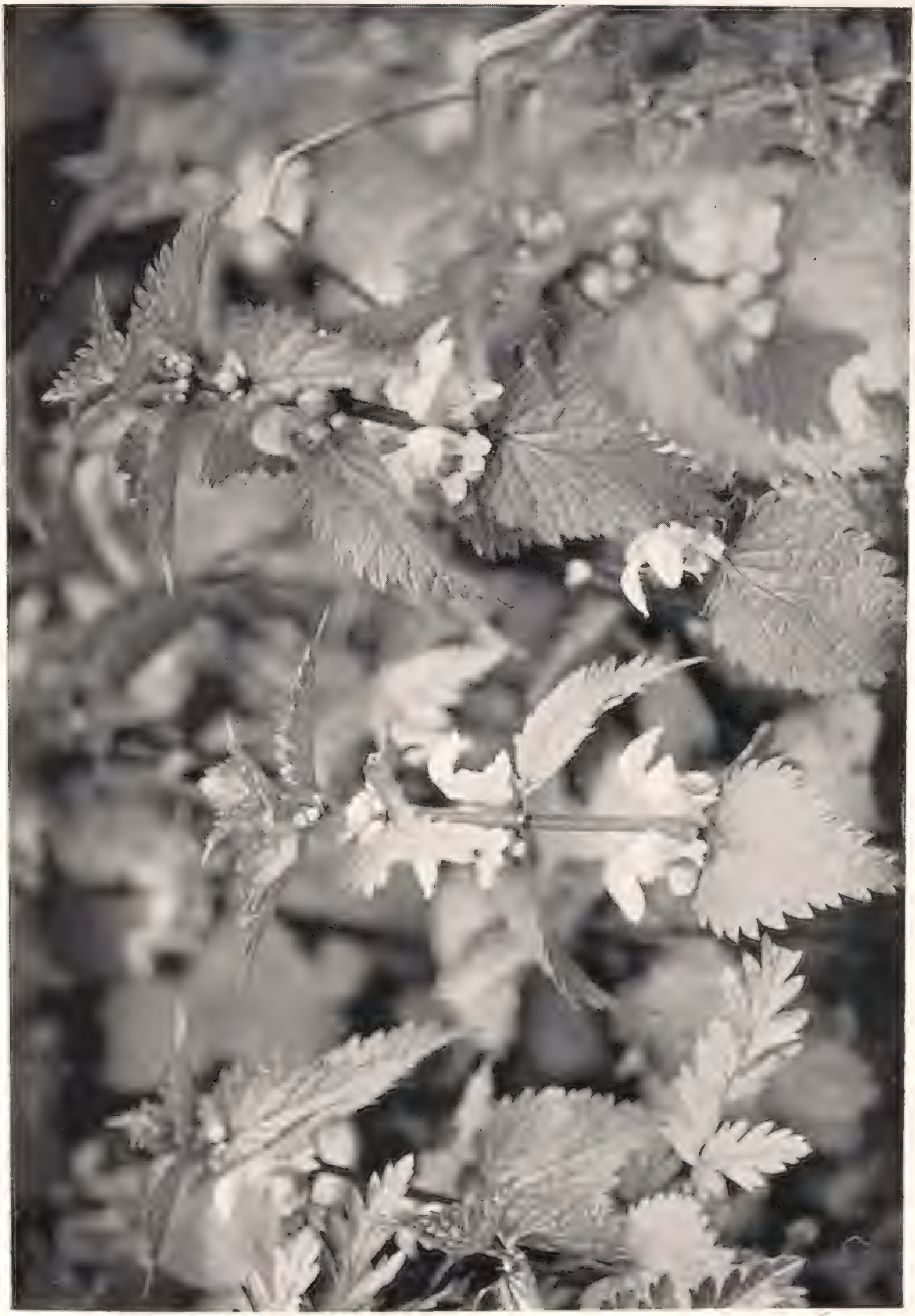
I sincerely trust, good readers, that a primrose, or any other wild plant, will mean a great deal to you. I hope wild flowers will always arouse in you the highest sentiments, and never cease to give you a sense of wonder and beauty. I desire to help you to know some simple, yet wonderful, facts about flowers, and I shall be disappointed if your love and reverence for them do not grow with your knowledge.

It is a great pleasure to know the names of wild flowers, to be able to recognize them as they appear in their seasons, and the field botanist is never so delighted as when he finds a new or rare plant in his district. But it is not enough to know the names of plants, you must understand their ways. Plants have ways of their own which make a most fascinating study. You like to read about the habits of different peoples; to hear stories about lions and tigers; to know the histories of rabbits, moles, frogs, newts, ants, or bees. All these have habits of their own, and so have plants. I have already told you some things about Daisies (pp. 3-7) which I am sure will interest you ; but other plants have different ways, and you can claim to know plants only when, in addition to being able to name them, you can describe their habits and tell their life-stories. It is nice to get together a collection of dried plants, neatly mounted and labelled, and arranged in proper order, but a dried plant does not tell you much of a story. A true naturalist studies living plants, watches them from day to day, sees their gradual growth, and knows from observation what they will do next. He can describe the clever devices by which they succeed in life ; how they attract useful insects and arm themselves against destructive ones ; how they compete with other plants for food, and light, and air. The naturalist is not satisfied with knowing that particular plants have certain kinds of roots, stems, leaves, flowers, and seeds ; he wants to know why they have such things. For instance, why does the Coltsfoot send up flowers before leaves, or the Evening Campion close its blossoms during the day, opening them and shedding its fragrance only at night ? Nature does nothing without a reason, and it is the study of Nature's reasons that provides the greatest interest.

Let me answer the two questions I have raised. The Coltsfoot sends up its yellow, dandelion-like flowers, each flower-head being a colony of tiny florets, before its leaves, for one reason, that it had leaves without flowers last year ; and for another, that it flowers very early in the year, when it needs all the sunshine that is going, and objects to being smothered either by other plants or its own big leaves. So the Coltsfoot gets its flowering done and its seeds formed before many later plants have put in an appearance or grown to any size. I might add other explanations of this habit of the Coltsfoot; I merely give these to show that explanations are to be found. The Evening Campion opens its beautiful white and fragrant flowers in the late evening and night because it desires the services of moths, which are usually about at the times the flowers are open. The whiteness of the flowers makes them visible in the gloom, and their sweet scent attracts the friendly insects. The moths visit the flowers to secure nectar, and in pressing into the flowers they become dusted with pollen grains. They pass from the male flowers, which bear pollen, to the female flowers, which need pollen to enable them to form seeds that will grow. The pollen is rubbed off their heads, "feelers," or legs on to the proper organ of the female flowers, and in this way, without intending it in the least, the moths serve the Evening Campion and many other plants.

Of course, you must know the names of the flowers that flourish in your localities, and I am going to give you some hints that will help you to identify plants you don't know. But make pets of a few plants. I mean exactly what I say—make pets of a few plants just as you would make pets of rabbits, mice, pigeons, or guinea-pigs. You can put your plant-pets in pots, and keep them in the house for observation; you may grow them in a special corner of your garden; or you can watch them as they grow in their natural haunts. Now, you are to keep your

PLATE 30



White Dead Nettle. *P.* 150.

PLATE 31

The Haunt of the Coot. *P*, 159.

plant-pets so that you may study their habits, and perhaps make some discoveries about them.

Perhaps I can make my meaning clearer by giving you an example. This year I have had three special plant-pets—the Coltsfoot, Gorse, and Rest-harrow. The Coltsfoot grew naturally in a corner of my garden, where I could watch it easily. The Gorse and Rest-harrow grew from seeds which I had planted in boxes. We will select the Coltsfoot for our example; how did it behave itself? The following observations transcribed from my Diary will give you an answer:

" *March* 1.—Noticed heads of Coltsfoot flowers breaking in little clumps out of the ground.

" *March* 4.—Coltsfoot heads turned sideways and slightly downwards. Stalks short and thick.

" *March* 7.—Two Coltsfoot heads open and held up to the sun. Stalks a little thinner and longer.

" *March* 9.—More flowers, all with heads turned upwards. The two heads noted on 7th have stalks still thinner and longer.

" *March* 12.—Dull day; no sunshine. Coltsfoot heads nearly closed and slightly drooping.

" *March* 13.—Bright sunshine. Heads erect, and visited by small flies.

" *March* 15.—Stalks quite ten inches long, slender. Heads drooping. Leaves coming, but quite small.

" *March* 16 *to* 25.—Heads still drooping. Petals fading.

" *March* 26.—Stalks show signs of stiffening. Heads trying to turn upwards. Appear like a shepherd's crook.

"*March* 31.—Heads nearly upright. Stalks quite stiff.

"*April* 5.—Heads now covered with seeds, and appear like dandelion "clocks." Stalks stiff and upright. Seeds carried away by wind. Leaves increasing in numbers and size.

"*April* 6.—Observed that leaves appear in clumps; they are stalked, but the plant shows no stem or branches. Dug about plant, and found stem and branches in form of underground runners, rooting at places."

These are not all the observations I made, but they are some of the most important. You will now see what you are to do with your plant-pets : watch them from day to day, and make notes of their doings in your notebooks.

But after you have made a complete set of observations, the time arrives when you must seek an explanation of the facts you have noticed, and it is just here that you reach the most delightful part of your study. You ask yourself, What am I to think about this peculiar pet of mine ? what are the reasons for its remarkable ways ? The following questions and answers in respect to the notes on the Coltsfoot will give you an idea as to how facts may be explained :

Why should the flower-stalks of Coltsfoot be at first so short and thick ? Because they need stoutness and strength to enable them to push their heads through the ground, and, further, they provide much substance for future growth.

Why are the heads at first turned downwards ? Because they break through the ground in that position, and in that way secure protection of their tender parts. The position is also an advantage to the growing flowers above ground. The green covering acts as an umbrella, keeping too much moisture away from the delicate parts.

Why do the flower-stalks get longer and thinner as the flowers mature? Because the plant is drawn up to the light, and in this way gets above surrounding vegetation, thus securing air and the attentions of insects.

Why do the flower-heads droop after holding themselves up for a time? Because the flowers have done a goodly part of their work. The male pollen has reached the female organs, and the seeds in the ovaries have been fertilized—that is, made capable of producing new plants. The plant is exhausted by this heavy work, and hangs its head like a tired child. But while the head is hanging the seeds are maturing, and they are protected while being formed by the natural umbrella made by the green receptacle.

Why do the heads hold themselves up again after the seeds are formed? Because they desire their seeds to be scattered to the best advantage. They hold them up to the wind, which loosens them and carries them away. The seeds have what is called a "pappus," which enables them to be wafted in the breezes like tiny parachutes. When there is a lull in the wind the seeds descend to earth, where they may grow if left undisturbed.

Why does the Coltsfoot have its seeds scattered in this way? Because the plants would be too crowded if the seeds were all planted near the parents. The seeds are sent away to form new Coltsfoot colonies.

These are just a few questions and suggested answers. They do not cover all the facts about the Coltsfoot, but they will give you an idea of the problems connected with plant-life, and how you may attempt to unravel them.

Do not have too many plant-pets at once. Two or three will give you plenty of work in a season; next season you can have two or three different ones, and in the course of a few seasons you will have gathered a great mass of interesting notes, and have found a lot of useful explanations.

You see, I want you to study a few plants in a very thorough way; that is better than studying a great many in an indifferent fashion. Learn to observe carefully and accurately. Don't jump to hasty conclusions. Have several specimens of the same kind of plant under observation, and see if the habit of one is the habit of all. Because you saw one man smoking, you would not say that all men smoked, and if you see one plant doing a certain thing, don't say that it is a common habit of its kind until you have seen other similar plants behaving in the same way.

Your notes will be of greater interest and value if they are illustrated by sketches. A series of photographs illustrating the life-history of a plant will be found of the highest value. It is also good to write short essays based upon your notes, and illustrated by your photographs and sketches. Your friends will surely read these with interest, and perhaps your essays may be worthy of publication. Why not try to make them so ?

I am not a collector of wild flowers, and I do not attach any great value to a collection of dried plants. But I am a keen botanist. I like to see the flowers growing, and to watch them as they grow. I take photographs of them, and have a diary in which I record their time of flowering and any peculiarities about them. My friends declare that my collection of photographs and lantern-slides is infinitely more interesting and helpful than any herbarium they have seen. But some of you may wish to form a collection of plants, and will be glad to have a few notes about collecting, drying, and arranging them.

For field-work you will need a vasculum, which is a flat tin box with a hinged lid, and usually furnished with a shoulder-strap. Your specimens can be kept fresh in this for hours. You can purchase vascula of various sizes from dealers in naturalists' requirements. If funds are low you can probably get a suitable tin box for the asking, and this you can carry in hand-straps. In gathering specimens you should secure complete plants, so that all their peculiarities may be shown in your collections. Flowers, stems, roots, leaves, seed-vessels, and seeds should all be represented.

When you return home after a day's collecting, take the plants out of your vasculum, and place them between sheets of botanical drying-paper, blotting-paper, or, if you have neither of these, newspapers cut to size will do. In placing the plants between the sheets, see that they (the plants) are not crumpled ; let the leaves and petals be laid out carefully, or, when they are dried, they will present a pitiful appearance. Pile your specimens thus laid between sheets one on top of another, put a suitable board of wood at the top and bottom of the pile, and then lay a weight on top of it. You must dry the plants under pressure of some sort. If you prefer it, you can do without the weight by using straps, and drawing them tight around the boards. You will have to change your drying-papers daily if you wish your specimens to be well preserved. It is advisable to place stout cards in the press between every three or four plants. When they are thoroughly dry, you take them out of your press and arrange them on sheets of clean paper, fastening them by thin glue or strips of gum-paper. A good size for your mounting-sheets is about seventeen inches by eleven inches, but the leaves of a cheap drawing-book may be made to serve very well. Then each specimen must have a label on which are stated the Natural Order and scientific name, as well as the popular name of the plant, also the locality in which it was found, and the date of finding.

The mounted specimens may be stored in boxes or portfolios; they should be kept in a very dry place. The specimens, of course, should be arranged according to their Natural Orders and genera, just in the order in which they are described in the "Floras," which are books containing an account of our wild flowers. The Rev. C. A. Johns' "Flowers of the Field" is such a book, and a very useful one for beginners to refer to.

Some plants dry quickly—say, in a day or two;

others require quite a long time in the press. Where roots are thick and full of moisture, like those of the carrot, they can be pared down, so that a thin section along their length remains. If the plants are very large, characteristic parts of them—roots, leaves, flowers, etc.—can be selected before pressing, and in this way all the necessary parts of the specimen can be got on to one sheet.

I can't help feeling annoyed when I see children, and sometimes grown-up people, gathering great quantities of wild flowers, only to throw them away when they are faded, or they are tired of carrying them. In collecting don't take any more specimens than you really need, particularly when the kinds are rare or uncommon. Botanists do not want our rare flowers to become extinct; on the other hand, they are anxious for them to increase. You can do good service by scattering seeds of rare plants in places where they are likely to grow and do no harm.

Let me tell you that there is no royal road to botany, no "serve-you-while-you-wait" method of gaining plant-lore. You can become a good botanist only by patient study, careful observation, and much experience in the field. Your knowledge will grow "line upon line, precept upon precept." Gain a little each day or each week, and you will in a few years have a wealth of knowledge that will never fail to give you pleasure. There are some things that you must learn before you can identify plants for yourselves; don't funk a few big words and some technicalities, rather get to know their meanings and uses. There are practical and interesting ways of learning botanical terms, as I think I shall manage to show you.

Without further preamble we will dive right into the thick of our subject. I am going to give you an account of the principal terms which are applied to the different parts of a flowering plant.

THE ROOT.—Is usually a tuft of fibres, each fibre being provided with a porous tip by which it absorbs food in liquid form from the soil. These fibres often radiate from a thickened portion of the root known as the main or tap root. The fibres are called *rootlets*. The following are some of the chief kinds of roots :

1. *The Bulb.*—A solid globular mass of substance, which produces rootlets from beneath, and leaves, etc., from above. The root of the Onion is a bulb.

2. *The Corm.*—A root like that of a Crocus. Unlike that of the Onion, which has circles within circles which can be peeled off, the corm is "all of a piece."

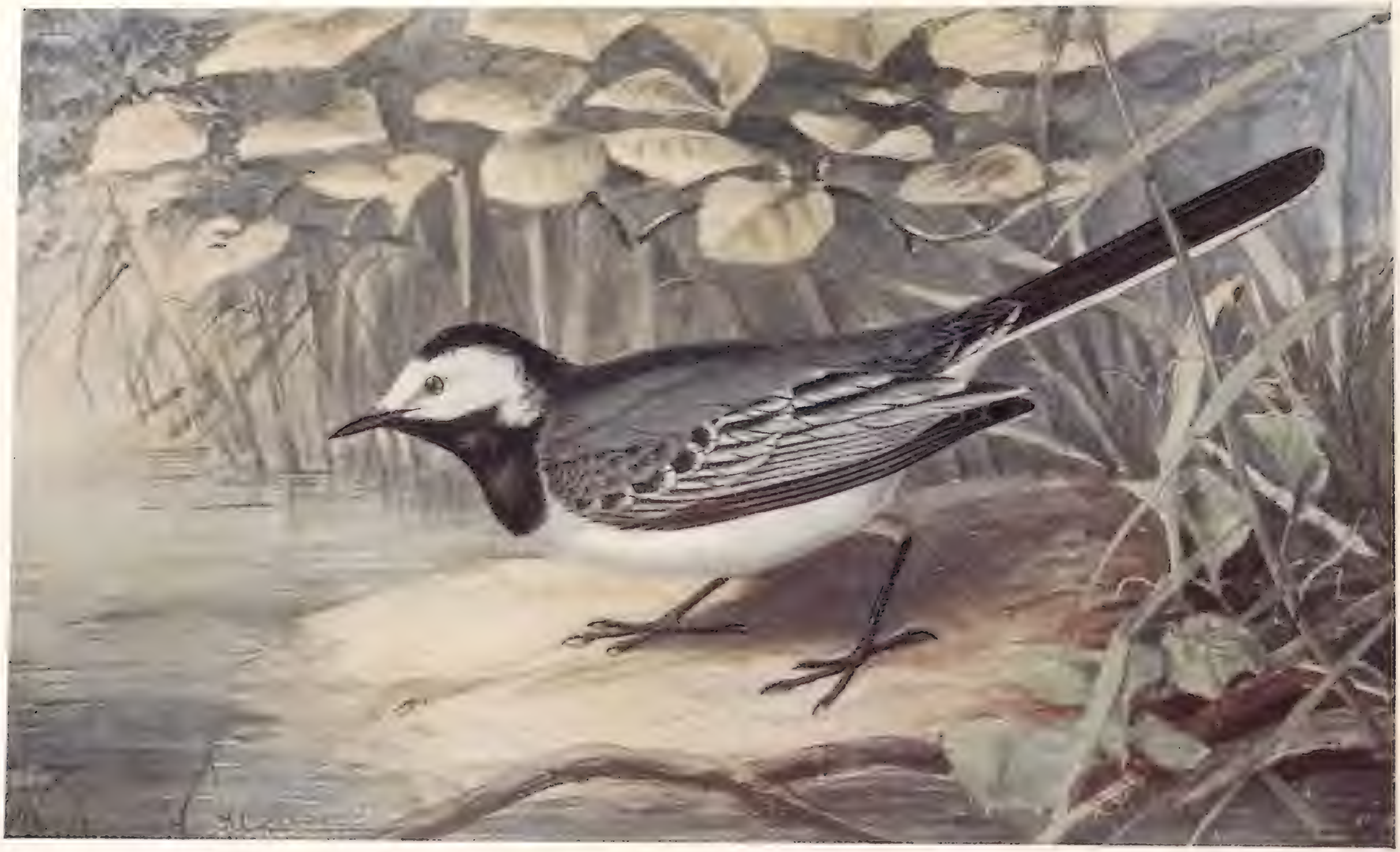
3. *The Tuber.*—A root which has one or more masses of substance, usually roundish in shape, which can produce other plants. Example : The Potato (Plate 51, *c*).

4. *The Spindle-shaped Root.*—Examples : Carrot and Beet.

5. *The Creeping Root.*—Example : The Great Bindweed.

6. *Aerial Roots.*—Roots which appear aboveground. Example : The rootlets springing from stems of ivy, by which the plant clings to trunks of trees or walls.

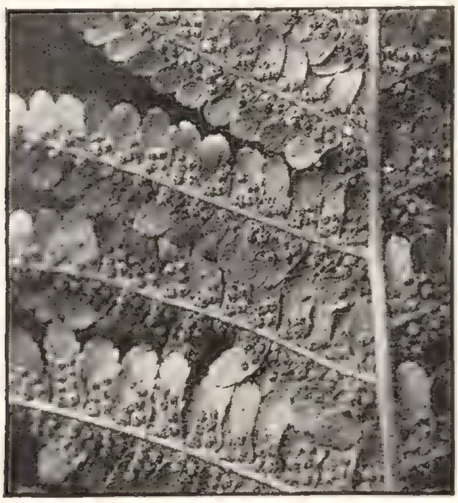
PLATE 32



PIED WAGTAIL. *See page 172.*

(*a*) Young Fern Plants.

(*c*) Moss Capsules. *P.* 178.



(*b*) Fern Frond, showing spore-cases. *P.* 177.

(*e*) Nest and Eggs of Common Sandpiper. *P.* 175.

(*d*) Yellow Iris. *P.* 176.

The Stem.—Stems may be *Subterranean* (underground) or *Aerial.* Underground stems form *Rhizomes,* or root-stocks, which send rootlets downwards and buds upwards. Examples: Anemone, Bog-bean, Iris. Tubers and bulbs are really underground stems, although they are often spoken of as roots, and have been referred to under "The Root." Aerial stems, as their name tells us, are those which grow above-ground.

Aerial stems are *simple* when they are without branches. Example: Grass of Parnassus. They are *compound* when branched. Examples: Knapweed, Flax Seed. The shapes of stems appear when they are cut crossways. They may be *round, semiround, triangular, square,* and in other forms. Stems may be:

1. *Erect.*—That is, perpendicular, upright. Example: Foxglove.

2. *Ascending.*—Horizontal when they first leave the root, but shortly becoming erect. Example: Dog-violet.

3. *Creeping.*—Stems which run along the ground and send rootlets down from joints. Example: The "runners" of the Strawberry.

4. *Prostrate.*—Lying on the ground, but not rooting. Example: Barren Strawberry.

Leaves.—The flat green part of a leaf is called the blade, or *lamina.* The stalk which bears the leaf is the *petiole.* The extension of the petiole into the blade and through to the tip or *apex,* is the *midrib.* Leaves have veins. When the veins run side by side from base to apex, the leaf is called parallel-veined; when the veins branch from the midrib and form a network in the blade, they are *reticulated.* Leaves are *simple* when they consist of one piece ; compound when they are divided into leaflets, as in the Clover or Horse-chestnut.

Leaves without stalks are called *sessile—i.e.*, sitting. A leaf of one stalk bearing three leaflets is *ternate ;* if it has five leaflets it is *quinate.*

Radical leaves spring immediately from the root. Stem-leaves are *opposite, alternate,* or *whorled.* Whorled leaves grow in whorls or circles round the stem.

When leaflets grow on opposite sides of a stalk, as in the rose, they are *pinnate* (*penna* = a feather). Pinnate leaves having an equal number of leaflets on each side of the midrib are *paripinnate.* When there is an odd leaflet at the end, as in the Rose, the leaf is called *imparipinnate.* Pinnate leaves are often twice divided in a pinnate manner, then they are *bipinnate.* If the divisions are again divided pinnately they are *tripinnate.*

Simple leaves are often *lobed.* Some lobes are *deeply cut.* A leaf having five or more narrow lobes joined near the stalk is *palmate* (hand-shaped). A leaf may be three, five, or seven lobed. Leaves lobed after the manner of pinnate leaves, but not divided into actual leaflets, are *pinnatifid* (cleft like a feather).

A *peltate* (*pelta* = a buckler) leaf has its stalk, or petiole, attached at or near its centre. Example : Nasturtium.

If the stalk passes through the leaf it is *perfoliate* (*per* = through, and *folium* = a leaf). Examples : Thorow-wax, Hare's-ear Cabbage.

Two leaves joined at their bases and having the stem passing through them are *connate* (*con* = together, and *nasci, natus* = to be born). Example: Yellow-wort.

The angle formed where a leaf springs from the stem is called the *axil.* A flower growing from this angle is *axillary.* Example: Germander Speedwell (Plate 29, *b*).

The margins of leaves must be studied. The margin is *entire* if not broken up by irregularities. It may be—

Sinuate.—Wavy. Example: Oak.

Crenate.—Having rounded teeth. Example: Ground Ivy.

Serrate.—Saw-edged. Example: Rose.

Dentate.—Toothed. Having sharp teeth pointing outwards. Example: Enchanter's Nightshade.

Spiny.—Sharp teeth. Example: Holly.

Ciliate.—Having a fringe of hairs. Example: Rock Rose.

The tip, or *apex*, of a leaf may be—

Acute.—Sharply pointed. Example: Bindweed.

Acuminate.—Tapering to a sharp point. Example: Nettle.

Mucronate.—Flattened, but bearing a sharp point, or *mucro.* Example: Common Vetch.

Obtuse.—Blunt, not pointed. Example: Oak.

Leaves assume many forms, and a great many terms are necessary in their description. I give some of those in common use. If I use any in describing plants that are not given here, the meanings will be found in the Glossary.

Subulate (*subula* = an awl) Awl-shaped. Example: The common Gorse.

Linear.—Long and narrow. Example: Garden Pink.

Oblong.—Long oval, equally broad at each end. Example: Rock Rose.

Elliptical.—Oval. About twice as long as broad. Broadest in middle and tapering to ends. Example: Leaflets of Rose.

Lanceolate.—Lance-shaped: long, narrow, and tapering to a point at each end. Example: Willow.

Orbicular.—Rounded. Example: Nasturtium.

Cordate (*cor* = the heart).—Heart-shaped. Example: Sweet Violet.

Obcordate.—Inversely heart-shaped; that is, a heart-shaped leaf turned about, with its base as it were at the apex, and *vice versa.*

Ovate.—Broad, rounded base; tapering towards the apex. Egg-shaped. Example: Corn Mint.

Obovate.—Inversely ovate. Example: Primrose.

Reniform (*renes* = the kidneys).—Kidney-shaped. Example: Ground Ivy.

Cuneate (*cuneus* = a wedge).—Wedge-shaped. Example: Leaflets of Tormentil.

Sagittate (*sagitta* = an arrow).—Like the barbed head of an arrow. Example: Arrow-head.

Hastate (*hasta* = a spear).—Spear-shaped. Like an arrow-head with the barbs turned outwards. Example: Sheep's Sorrel.

Triangular.—With three angles, and three sides. Example: Danish Scurvy Grass.

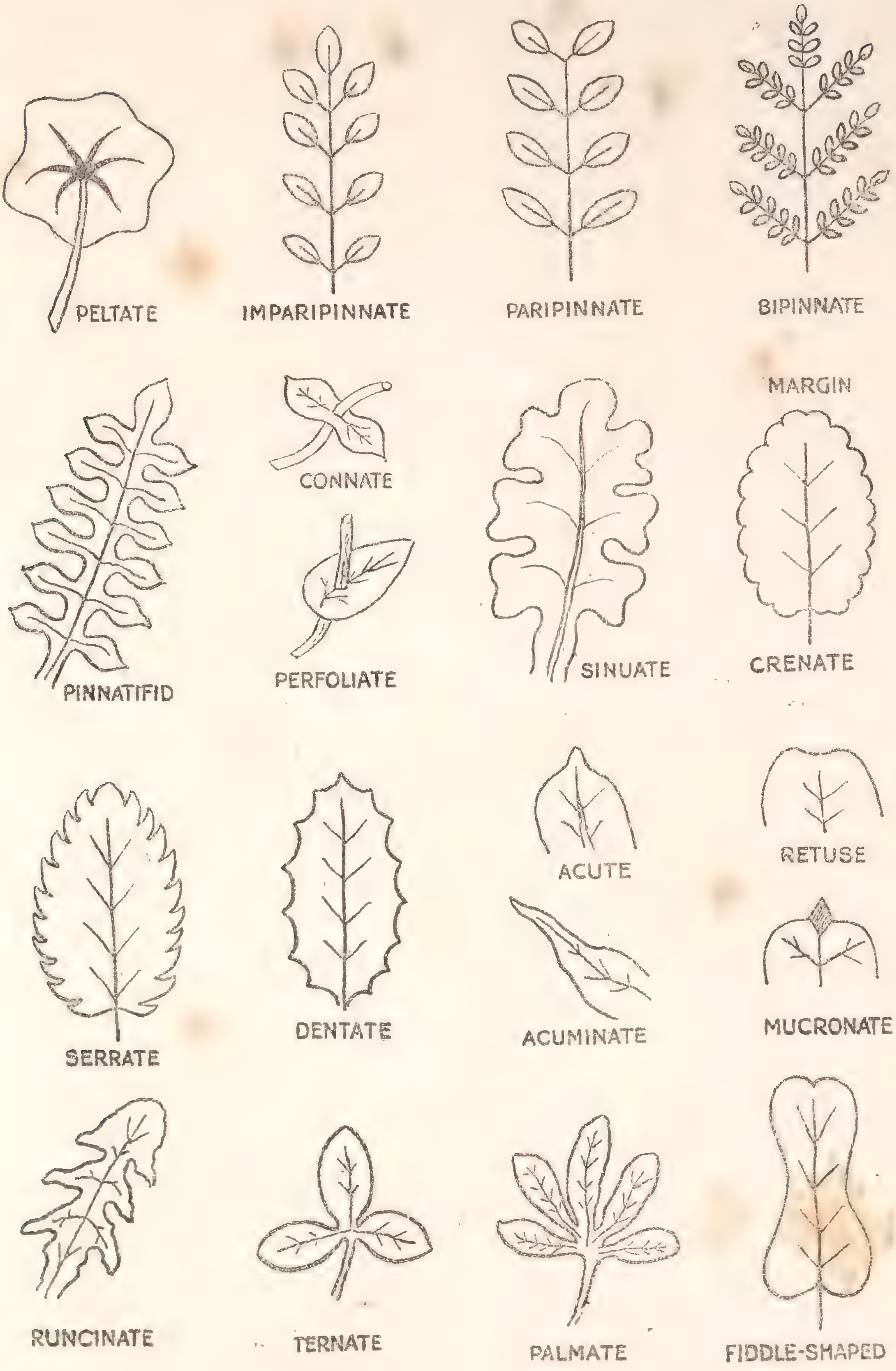


Fig. 44.—Some Forms of Leaves.

Spathulate (*spatula* = diminutive of *spatha*, a broad blade).—Spoonlike. Oblong, with a long haft. Example: Daisy.

For some diagrams of forms of leaves and their margins and apices, see Figs. 44 and 45.

STIPULES.—If you examine the leaves of the Rose, you will see two leaf-like growths at the base of the petiole, or leaf-stalk, just where it joins the stem. These growths are called stipules (*stipula* = a stalk). Stipules occur on many plants, and the leaves which bear them are described as *stipulate.*

BRACTS.—These are small leaves, differing from the other leaves of a plant. They are generally situated beneath the flower. They are occasionally scalelike, as on the stalks of the Coltsfoot. In compound flowers, such as the Daisy, the bracts are numerous at the base of the flower-heads, and form a kind of cup. Bracts in such a form compose an *involucre* (*involvo* = to wrap up). The bracts of the involucre are wrapped about the flowers before they expand.

FLOWERS.—Flowers are the most important parts of plants, for by their agency seeds are formed, and future generations made possible. They are very wonderful in structure. You must get to know all the parts of a flower and understand their uses. Pluck a few buttercups, and examine them carefully. Each flower consists of the following parts:

1. *Calyx* (Greek, *kalux ; kalupto* = to cover).—This consists of fine, small, green leaves, called *sepals*, which cover the flower in its bud stage.

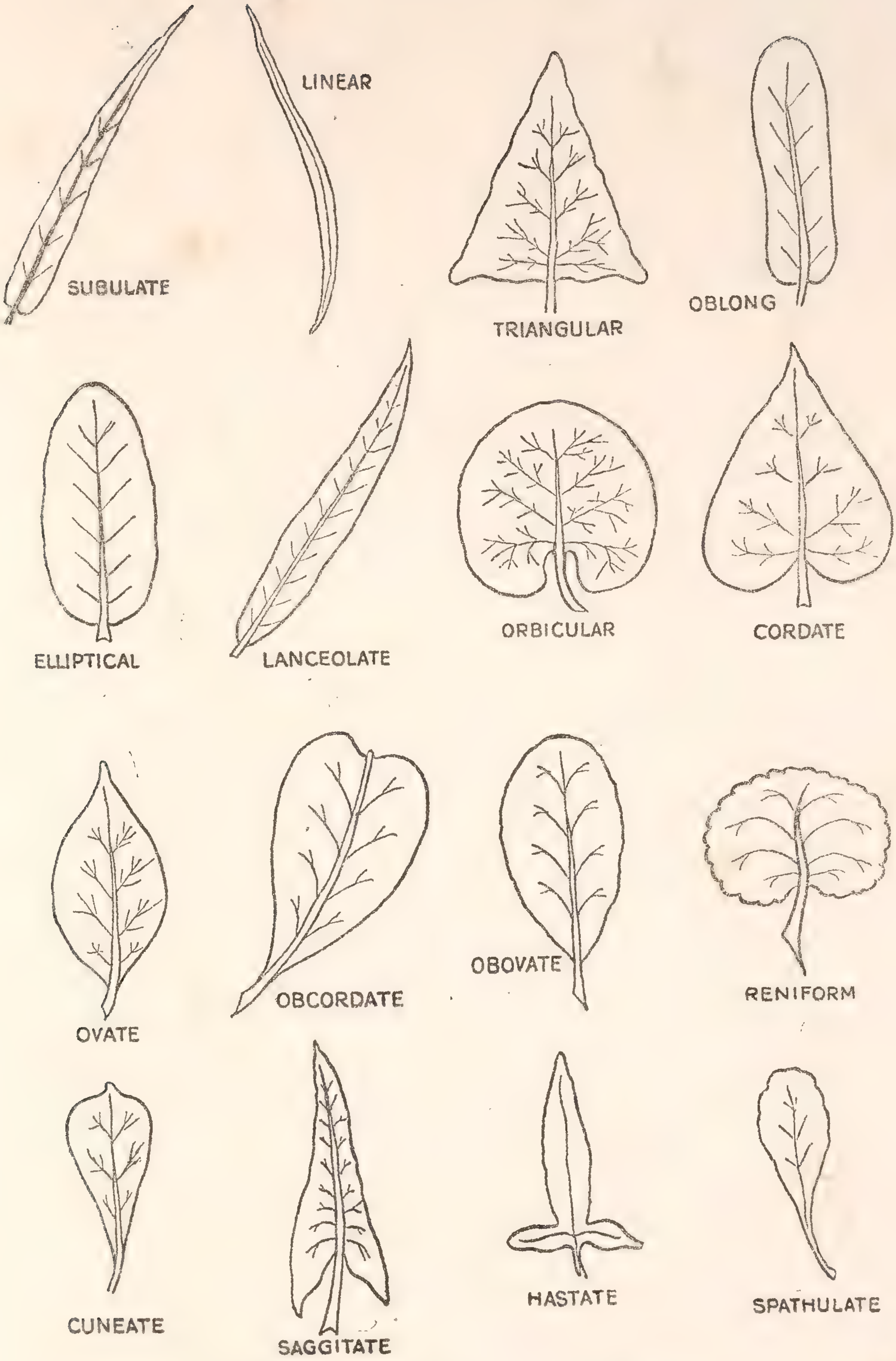


Fig. 45.—More Forms of Leaves.

2. *Corolla* (a little crown).—This consists of five yellow petals, which make the most showy part of the flower.

3. *Stamens* (*stare* = to stand).—When you remove the petals you will notice a number of little stalks bearing yellow heads containing a kind of dust. These are the male organs of the flower, and are called "stamens." The little stalks are called *filaments ;* the heads, bags, sacs, or boxes borne by the filaments are known as *anthers*, and the dust contained in the anthers, and shed by them, is the *pollen*.

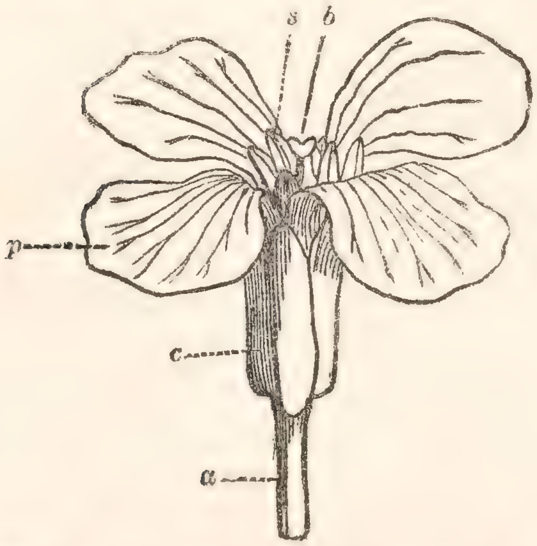


FIG. 46.—FLOWER OF WALL-FLOWER.

a, Flower-stalk ; *c*, calyx ; *p*, corolla ; *s*, stamens ; *b*, stigma. (After Balfour.)

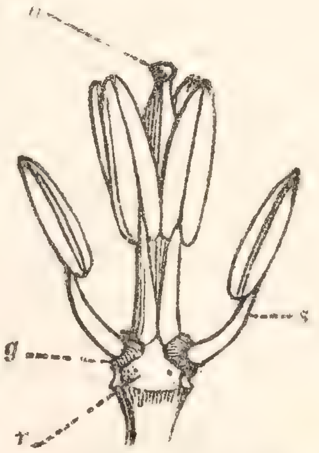
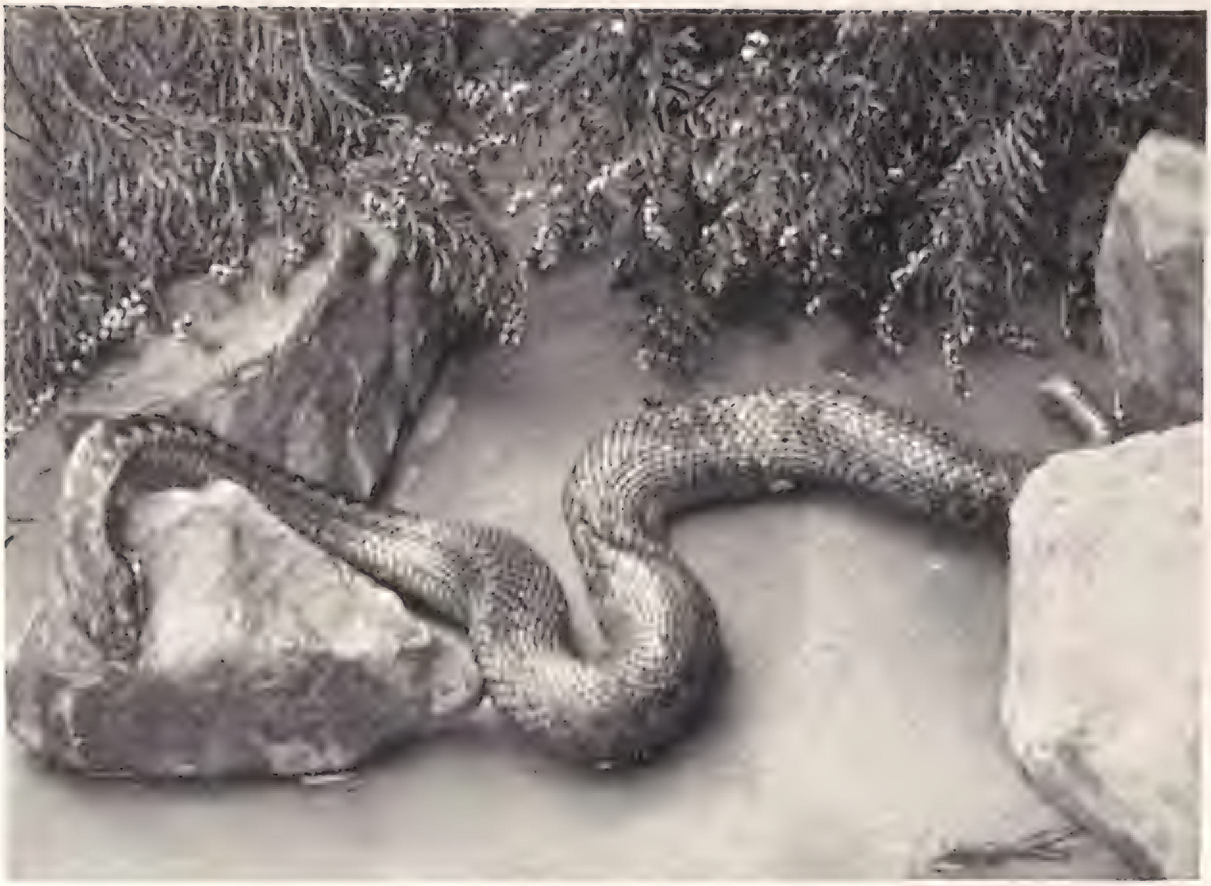


FIG. 47.—SAME FLOWER, WITH CALYX AND COROLLA REMOVED.

s, Stamens ; *b*, stigma at top of pistil ; *r*, receptacle ; *g*, honey-glands at base of short stamens. (After Balfour.)

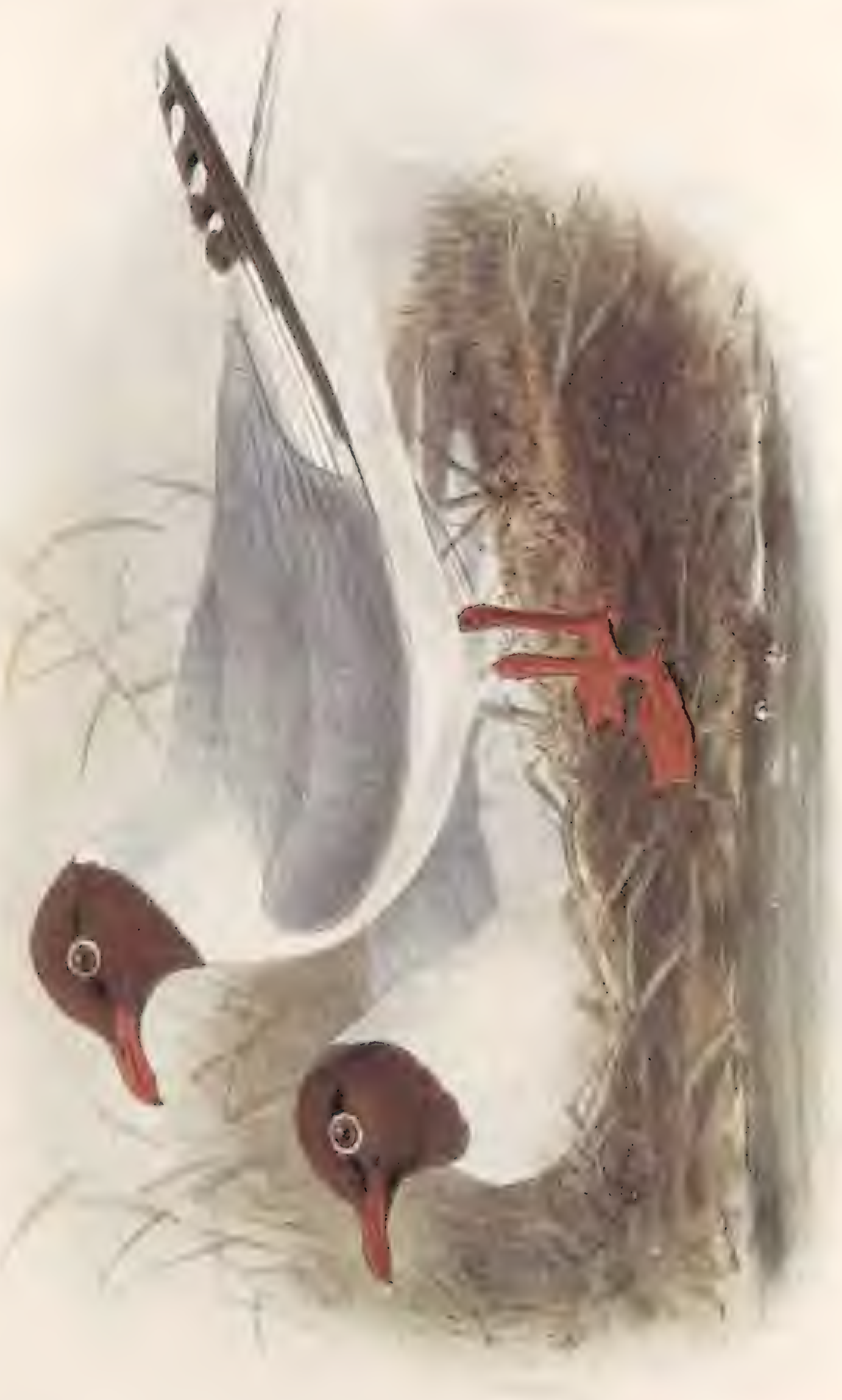
4. *Pistil*.—Remove the stamens, and you will see the central part of the flower, consisting of a number of clustered green *carpels* (Greek, *karpos* = a fruit). These carpels form the *pistil* or female part of the flower. In the carpels are *ovules*, which become



(*a*) Adder. *P.* 180.

(*b*) Primroses. *P.* 187.

PLATE 35



Black-headed Gulls. *See page 173.*

seeds. Examine a Primrose, and you will find a different form of pistil. You will see it consists of three parts: (*a*) An ovary at the base, containing ovules; (*b*) a stalk called the *style*; (*c*) a knoblike organ on the top of the stalk, known as the *stigma.* Before ovules can become fertile seeds, pollen from the anthers must lodge on the sticky stigma. A narrow tube is made from the stigma to the ovary, and through this tube the pollen grains inject a fluid. This fluid fertilizes the ovules, which develop into seeds. In the buttercup, each carpel bears its own stigma, which is connected with it by a very short style.

Some flowers have but one outer covering; that is they do not have both calyx and corolla. It is then difficult to decide whether the covering, or *envelope*, is to be called a calyx or a corolla. This difficulty is overcome by using the term *perianth* (Greek, *peri* = around; *anthos* = a flower). Example: Tulip.

Stamens and pistils are not always present in the same flower: in that case pollen is carried from the staminate to the pistillate flowers by insects or wind. Many flowers object to self-fertilization, and so have wonderful arrangements to secure cross-fertilization.

A flower bearing stamens, but no pistil, is called *barren.* Pistillate flowers are *fertile.*

The RECEPTACLE is that part of a flower on which all the other parts rest. It is very distinct in compound flowers like the Daisy or Thistle.

The NECTARY, as its name implies, is a nectar or honey vessel. Buttercups have a scalelike nectary at the base of each of their petals.

The arrangement of the flowers upon the stem is called the INFLORESCENCE. There are many kinds of inflorescence, as the following notes show :

Axillary.—Flowers springing from angle between main stem and leaf (Speedwell, Plate 29, *b*).

Terminal.—Flowers at end of main stem, no leaves being beyond them (Daisy, Plate 3).

Scape.—Flower-stalk springs straight from root and bears no leaves (Primrose, Plate 34, *b*).

Spike.—Stalk bearing number of sessile flowers, one above the other (Fig. 48).

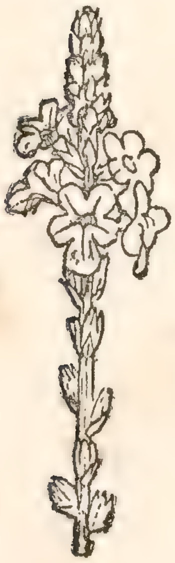


FIG. 48.—SPIKE OF VERBENA.

Raceme.—Flowers arranged as in spike, but each flower has a simple stalk (Currant, Fig. 49).

Panicle.—A compound raceme (Oats).

Corymb.—(Greek, *korumbos* = a cluster of flowers.) A raceme with stalks getting shorter as they approach the top. The flowers are thus brought almost to a level (Fig. 50).

Umbel.—Flower-stalks rise from common centre, each stalk bearing a single flower (Ivy). A *compound umbel* occurs when each stalk bears another umbel instead of a single flower (Carrot, Fig. 51).

Cyme.—Irregularly branched stalks, but flowers almost on a level (Elder; Upright St. John's Wort, Plate 14, *b*).

Capitulum, or Head.—Flowers stalkless, on a flattened receptacle (Daisy, Plate 3).

Catkin.—Crowded spike of flowers of one sex. Each tiny flower protected by a scalelike bract instead of ordinary perianth (Hazel, Fig. 52).

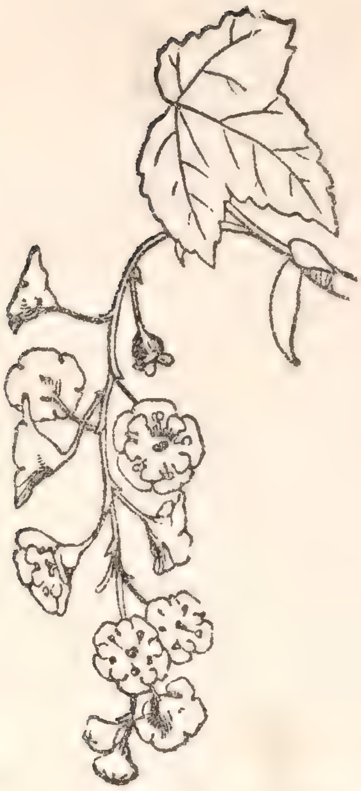


Fig. 49.—Raceme of Currant.

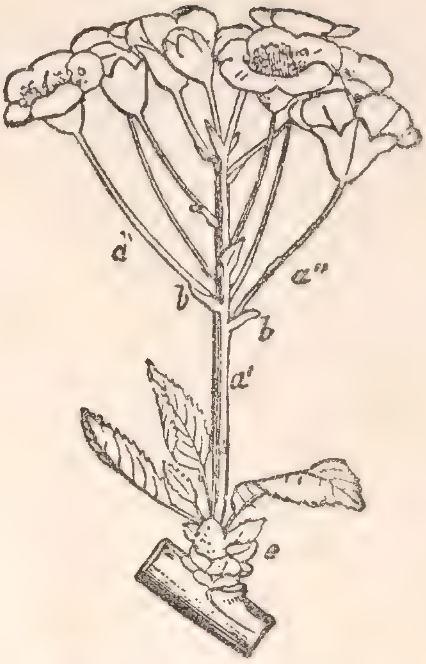


Fig. 50.—Corymb.

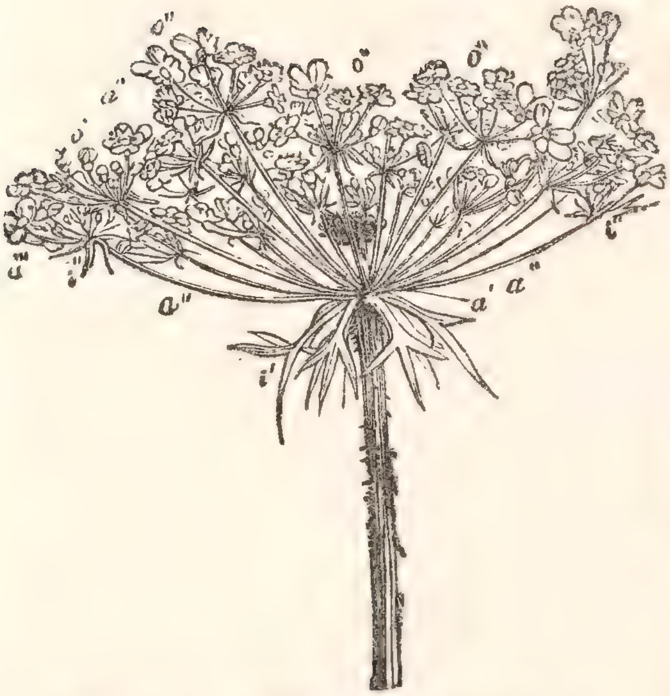


Fig. 51.—Compound Umbel of Carrot.

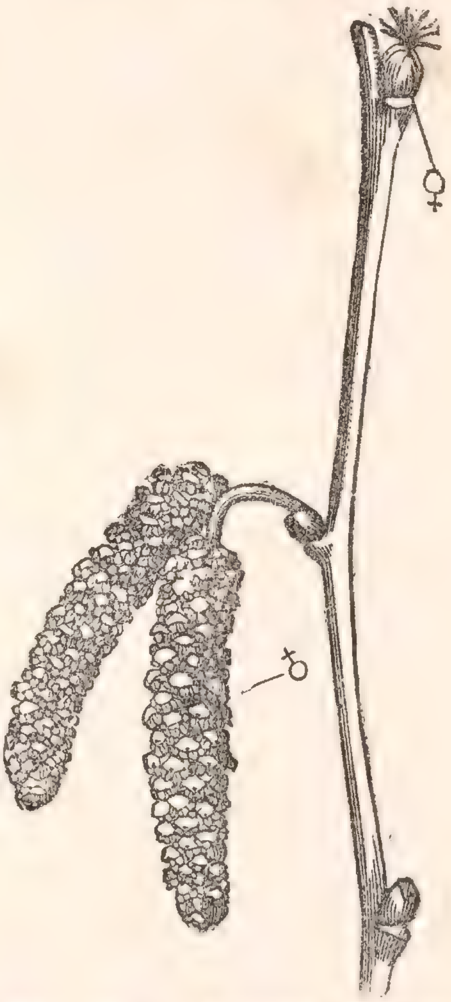


Fig. 52.—Male Catkin of Hazel (♂); Female Flower of Same (♀).

Fruits.—When the ovules have been fertilized by pollen, the flower withers; the ovary swells and develops into fruit. The fruit consists of a seed, with its covering styled the *pericarp* (Greek, *peri* = around; *karpos* = fruit). There are many forms of fruit. I mention some principal forms.

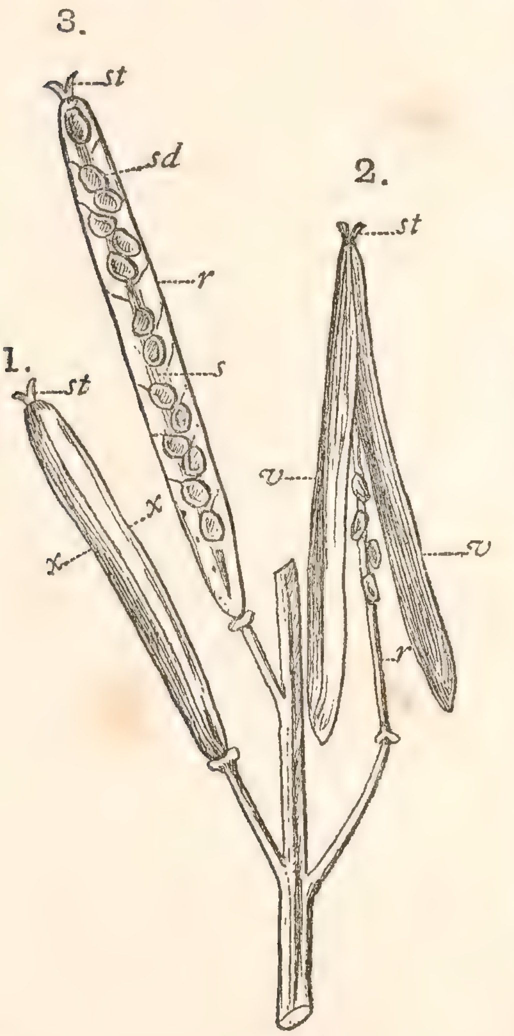


Fig. 53.—Three Mature Fruits (Siliques) of the Wallflower.

1, Fruit still closed. 2, Fruit opening. *v*, *v*, The open valves; *r*, replum, seen edgeways, with seeds attached. 3, Fruit from which valves have dropped off.

The *Legume*, or pod, bearing seeds in a single row, and not having a partition (Pea and Bean).

Silique.—Long, podlike, having edges connected by internal membrane (Wallflower, Fig. 53).

Silicle.—A short, broad silique (Penny Cress, Plate 14, *c*).

Capsule.—A dry seed-case, usually many-seeded (Campion, Fig. 54).

Berry.—Seeds enclosed in pulp. Fruit succulent (Currant, Grape).

Drupe.—Stone fruit. A nut, or "stone," embedded in pulp (Plum).

Cone.—Overlapping scales: each scale covering two seeds (Fir).

Nut.—Pericarp woody, or leather-like (Hazel, Beech).

The Seed.—When a seed is composed of two lobes, such as can be seen by splitting a bean or pea, it is called *Dicotyledonous* (Greek, *dis* = twice; *kotyledon* = a cap). The *plumule*, or embryo, of the future plant is enclosed between the two cotyledons. Plants having seed of this kind are classed as Dicotyledons. When the substance of the seed cannot be divided into two parts in this way, the seeds are *Monocotyledonous* (Greek, *monos* = one, and *kotyledon*). Plants bearing such seed are classed as Monocotyledons. With few exceptions, the monocotyledons have leaves with parallel veins, and the parts of the flowers are usually arranged in threes. The Vegetable Kingdom is divided into three great Classes: Dicotyledons, Monocotyledons, and Acotyledons. The latter are sometimes called "flowerless" plants; they embrace Fungi, Lichens, Seaweeds, Liverworts, Mosses, and Ferns.

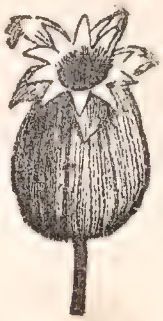


Fig. 54.—Capsule of Campion.

I don't ask you to sit down and learn by heart all the technical terms and the explanations I have given; that would be the very worst way in which to get to know them. There is a far better and more interesting way. Take your vasculum, and go out into the country; collect some plants; take them home and examine them. What kinds of roots have they? and how many kinds of roots have you collected? Make rough sketches of the roots, and write the descriptions under the sketches.

Suppose you have got a specimen of the Wild Carrot, root and all—sketch the root and write: "Spindle-shaped root of Wild Carrot" as a description. I know that once I have photographed a plant, its name and form is indelibly fixed in my memory; and I am sure that once you have sketched a root, or any other part of a plant, if you have used the right term in description of your sketch, you will always remember it.

Sketch and describe leaves, stipules, bracts, flowers, and inflorescences. Do the same with fruits and seeds. Even when you are not out on a collecting excursion, but are walking along the road on some errand, or strolling round the garden or park, take note of the plants you pass. Say to yourself: "That Rose has pinnate leaves; its leaflets have serrate margins, and I see stipules at the base of the leaf-stalks." Or, "I wonder what is the proper term to use in describing the inflorescence of the flowering Currant which I see just here? I must look it up when I get home." Take notes by the way; ask yourself questions and ferret out the answers; that is the way to make progress in any study.

A good way to get familiar with the forms of leaves is to make prints of them on photographic paper. Get a photographic printing-frame with a piece of clean glass which fits it. An old negative, with the film removed, does admirably. Place your leaf carefully on the glass, then lay your paper face downwards on the leaf; close the frame, and expose to the light. After a good exposure the uncovered portions of the paper will be very dark.

When you think the exposure has been long enough, remove the paper from the frame, and you will have a beautiful print of the leaf, showing veins and a great deal of detail. The paper must, of course, be toned and fixed. In this way you can use a pleasant hobby to advance your botanical knowledge. Gather your finished prints together and store them in albums, portfolios, or boxes. You will be astonished at the beauty of such prints, and in making and naming them you will have learned some useful facts. The paper known as "self-toning" is simpler to deal with than ordinary printing-out-paper (P.O.P.); it only needs fixing in a solution of hypo, an hour or so's washing, and the "messy" part of the work is done.

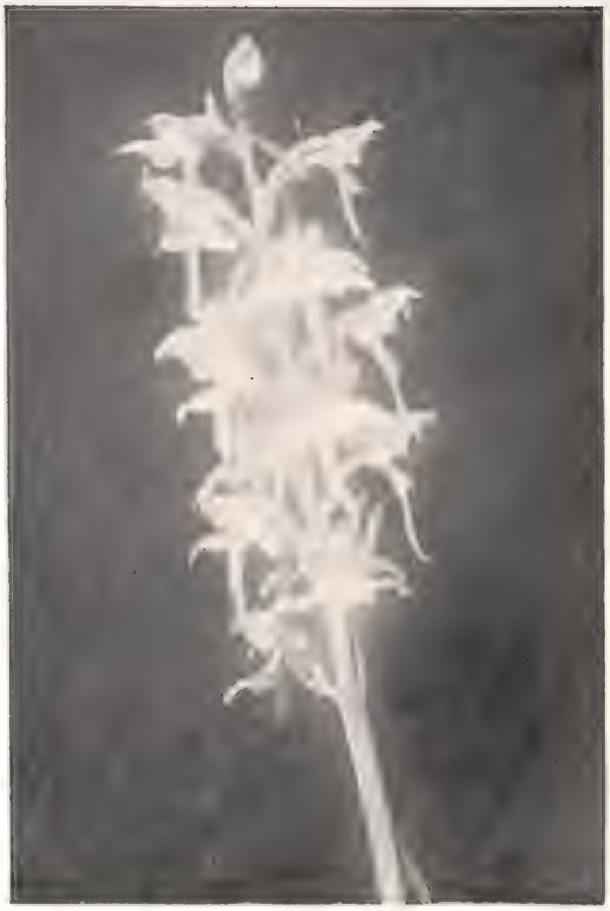
But ordinary P.O.P. and self-toning papers cost money, and money is always a consideration with young people. Is there no cheaper way of making prints of leaves? Well, there is, and I will tell you about it.

There is a kind of paper known as "Ferro-prussiate." This is the sort that is used by draughtsmen in making copies of their drawings. It is far less expensive than ordinary P.O.P., and yet it will give you splendid *blue* prints. I have some prints of leaves made on this kind of paper by me as I write; they are really beautiful; every detail is shown. You can get a supply of "Ferroprussiate" paper from dealers in artists' materials and draughtsmen's supplies. Perhaps you have some draughtsman friend who can give you some odd pieces to experiment with. The leaf and paper are put into a printing-frame just as with P.O.P., and printing is best carried on in good sunlight. The paper is green, but it prints blue, and it may be removed from the frame when the details of the leaf are distinctly visible. After printing, the paper is placed in cold water, when it soon turns bright blue, and the details become more distinct. The print should be washed in several changes of water until there is no yellowness about it; then it may be allowed to dry. When dry, it is ready for naming and its proper place in the collection.

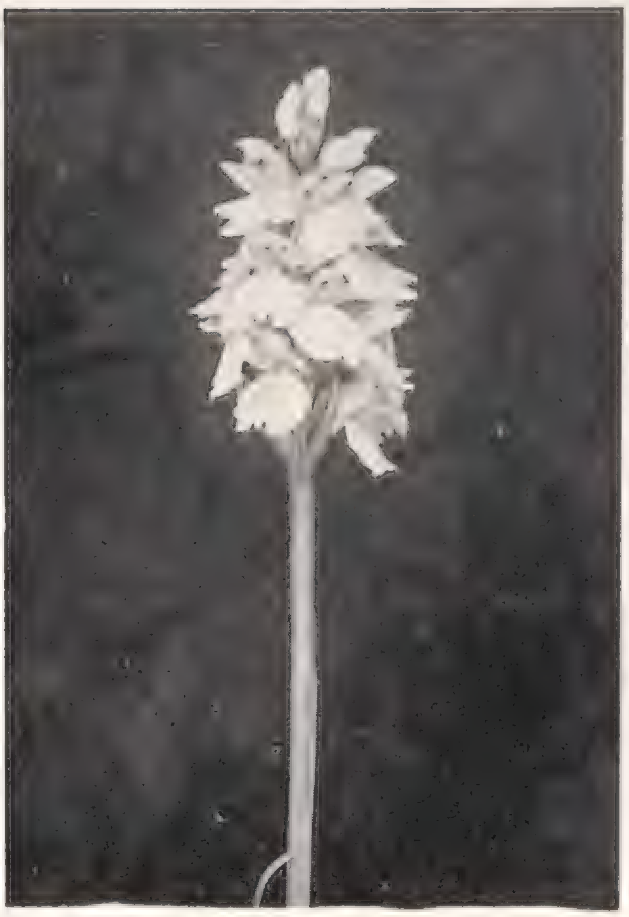
You can make Ferroprussiate paper yourselves if you like. This is how to do it. Get from the chemist 40 grains of ferricyanide of potassium and 1 drachm of ammonio-citrate of iron in separate packets. Dissolve the ferricyanide in 5 drachms of water, and the ammonio-citrate in a similar quantity. Keep the solutions apart until required for use. When you want to prepare your paper, you must work at night by artificial light. Have some nice, smooth-surfaced, but not glazed, paper ready; mix your two solutions, stir them well, and strain the mixture through muslin. You will then have a green solution, which you must spread nicely and evenly with a wide brush over one surface of your paper. Let the paper dry in the dark, and keep it under cover until you wish to use it. Print as already directed. I need hardly say the solution is not good to drink, and it should not be left carelessly about.

If you have the good-fortune to possess gardens, why not grow some wild flowers in them? I have a nice corner of my own garden devoted entirely to wild flowers of the rarer kinds. When I want to

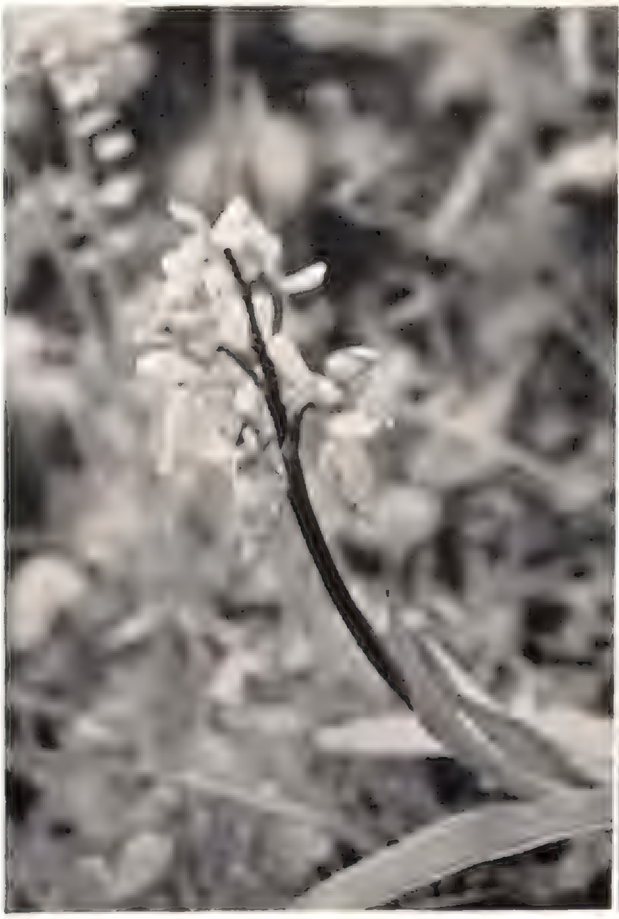
PLATE 36



(*a*) Butterfly Orchis. *P.* 192.



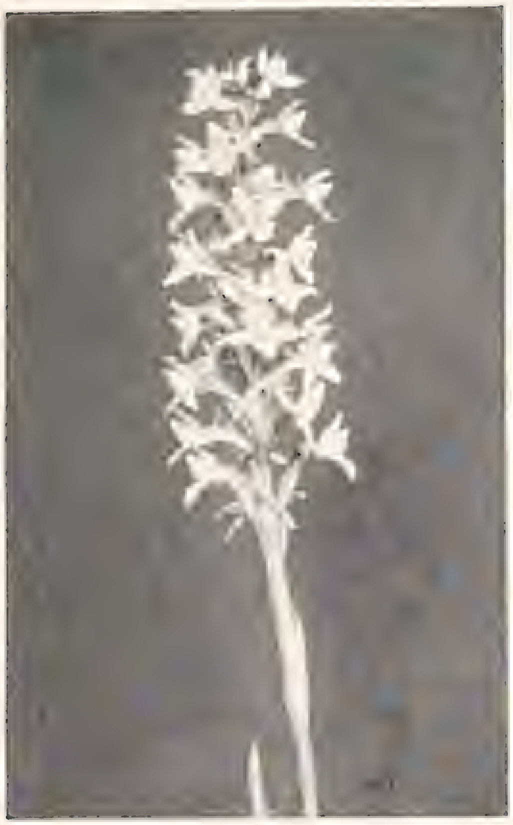
(*b*) Spotted Orchis. *P.* 191.



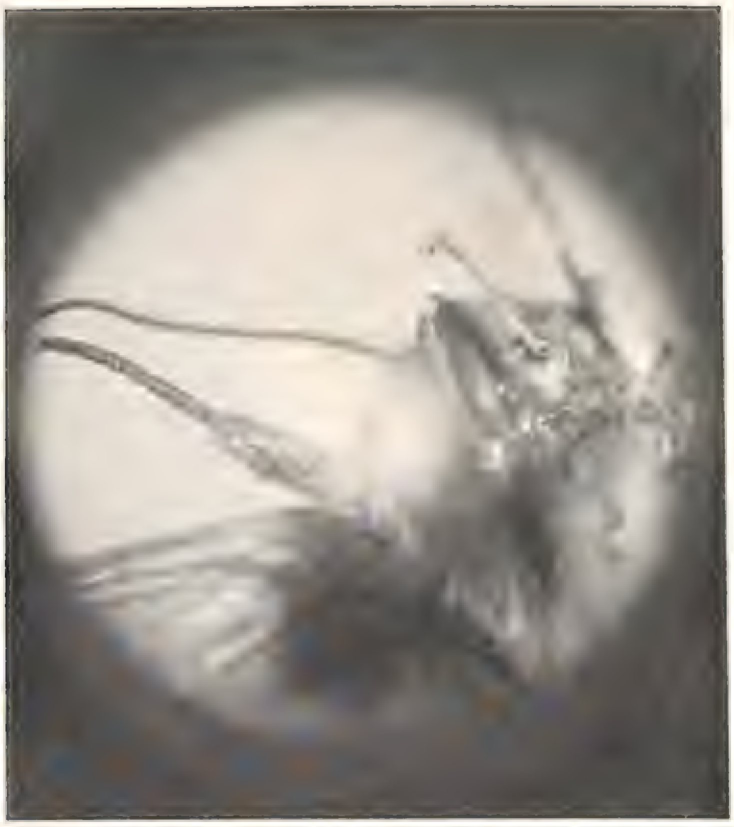
(*c*) Early Purple Orchis. *P.* 188.

(*d*) Marsh Orchis. *P.* 191.

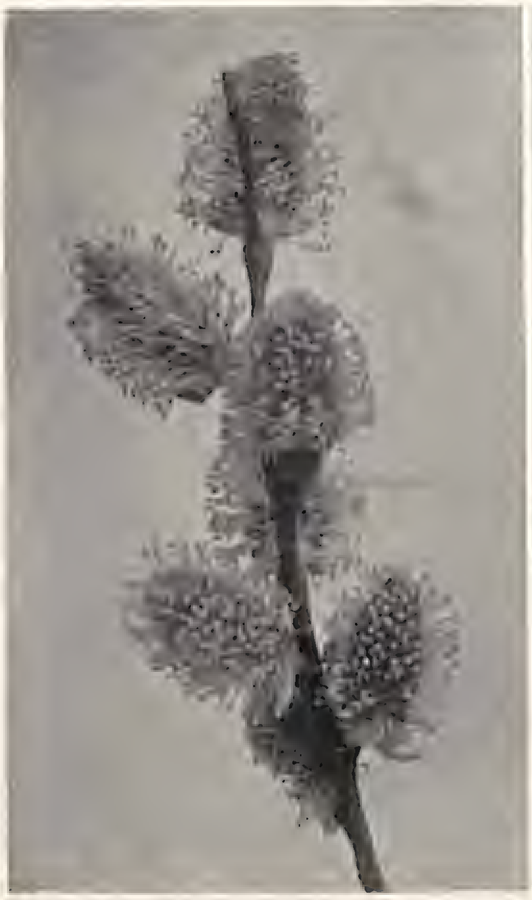
PLATE 37



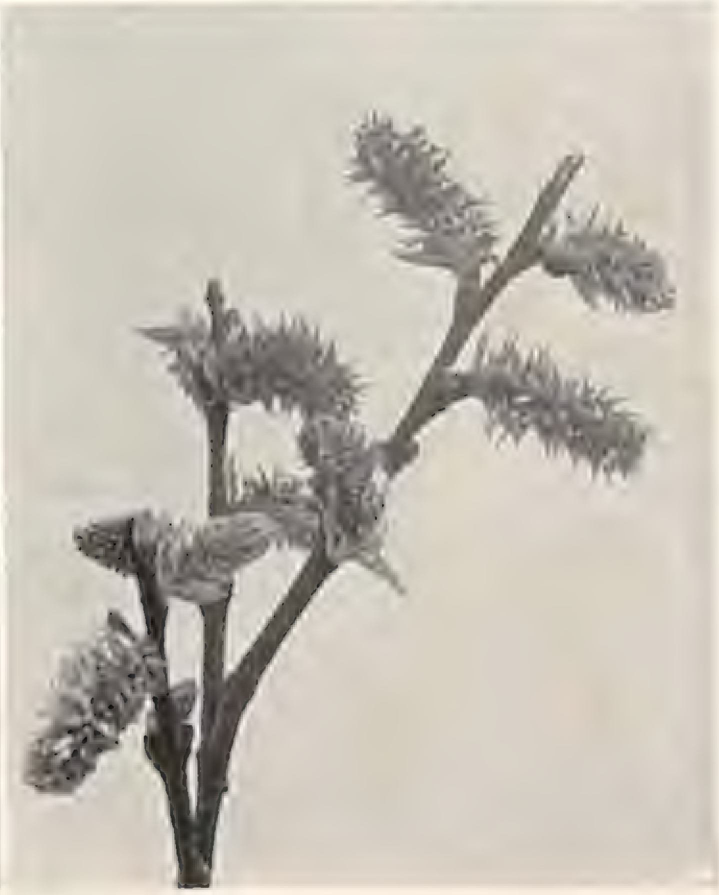
(*a*) Fragrant Orchis. *P.* 191.



(*b*) Head of Moth bearing Pollinium of Orchis. *P.* 191.



(*c*) Sallow Catkins (male). *P.* 195.



(*d*) Sallow Catkins (female). *P.* 195.

study any particular plant, I grow specimens of it in my garden, and thus have them handy for observation. A friend of mine had one of the loveliest wild-flower gardens one could imagine. He had his plants arranged in proper botanical order, and they grew in wonderful profusion. He had a pond for water-plants, and a rockery for such as grow among the mountains. Alas! for me, but not for him, that excellent friend and botanist is now in the "Happy Land"!

By the way, don't despise common flowers. They are not one bit less interesting than rarities. The commonest plant of the wayside has its story to tell, and its little secrets that no one has yet learned.

I want you to be able to identify flowers by yourselves; that is why I have introduced so much technical matter into this chapter. You cannot identify plants unless you understand the terms in which they are described by botanists. By practical use, botanical terms will become second nature to you; they will cease to present any difficulties, and the time will come when you will realize how valuable they really are. I shall give you a lesson on identification in the next chapter.

BOOKS TO READ OR CONSULT.

The Romance of Wild Flowers. Step. Warne and Co. 6s.
Types of British Plants. Colman. Sands and Co. 2s. 6d.
The Story of the Plants. Grant Allen. Newnes. 1s.
Nature Studies (Plant Life). Scott Elliot. Blackie and Son. 3s. 6d.
A Plant Book for Schools. Darbishire. A. and C. Black. 2s. 6d.
Plants and their Ways. Evans. Dent. 1s. 4d.

CHAPTER VI

HOW TO IDENTIFY WILD FLOWERS

I HAVE had a lovely ramble this morning, and have seen a lot of things I am almost bursting to tell you about; indeed, I could make a big book out of the plants, insects, birds, and other animals that I noticed. But I must restrain myself, for my real object in going out was to get a few plants by which I can give you a lesson in finding out the names of plants you do not know. I have quite a lot of interesting plants in my vasculum; I dare say you know some of them already. Now, here is a plant. Can you tell me what it is? "Oh, that is a small Dandelion!" you say. You have made a great mistake. There are a goodly number of flowers that the unskilled call Dandelions, and you have fallen into a common error. Compare this plant with the Dandelion I have here. You can see at once that they are very different. This plant has a rosette of radical leaves; they are oblong, and have an entire margin. You will see their upper surface bears a number of long hairs, and underneath there is a sort of starry down. The leaves of the Dandelion are also radical, but they are longer than those of the plant we are examining. Besides, they are deeply cut; they have sharp lobes pointing backwards, and they bear no hairs either above or beneath. The leaves of the Dandelion are described as *runcinate*. The plant gets its common name from their shape; their lobes have some resemblance to lion's teeth, and the name "Dandelion" comes from the French *Dent-de-lion* = lion's tooth.

You must not jump to hasty conclusions, or you will make many mistakes. The plant which you thought to be a small Dandelion is really the Mouse-ear Hawkweed. Both plants belong to the same Natural Order; they are compound flowers; but they belong to different *genera*, or families. You can see other differences than those I have called attention to; the heads of the Mouse-ear Hawkweed are smaller than those of the Dandelion, and if you look underneath the strap-shaped petals, you will notice they are tinged with red; and the flower as a whole is lemon-coloured, and brighter than the Dandelion. The Mouse-ear Hawkweed, too, does what the Dandelion is not able to do: it sends out creeping runners (*scions* or *stoles*) from the crown of its root, and these scions root at intervals, like those of the strawberry. We have many Dandelion-like flowers that are not Dandelions. The Hawkweed family has many species, and its species often vary in some details. On the whole, they are about as troublesome a lot as you are likely to meet with. I have spent many a brain-splitting hour in the effort to determine the name of an uncommon variety.

Now, how are you to go about the work of identifying flowers?

To begin with, you must either possess or have access to a good "Flora." When I was a boy I puzzled out many a species with the aid of Babington's "Manual of British Botany." Now, I find Bentham and Hooker's "British Flora" of the greatest value. But perhaps as good and simple a book as young folk can use is Johns' "Flowers of the Field" in its latest edition. I think you should save up your pocket-money to get "Johns"; the cost is seven and sixpence.

In Routledge's 1908 edition of "Johns" the natural arrangement of Flowering Plants is thus presented:

CLASS I. DICOTYLEDONS.—Seeds composed of two cotyledons. Leaves generally net-veined. Parts of flowers in fours, fives, or multiples of four and five.

SUB-CLASS I. THALAMIFLORÆ.—Flowers have calyx and corolla; petals distinct, and, in common with stamens, grow separately from sepals. Stamens grow from base of ovary.

SUB-CLASS II. CALYCIFLORÆ.—Flowers possess calyx and corolla. Petals distinct. Stamens inserted in calyx, or near to its base.

SUB-CLASS III. COROLLIFLORÆ.—Flowers have calyx and corolla. Petals joined. Stamens fixed on petals.

SUB-CLASS IV. MONOCHLAMYDEÆ (Greek *monos*, one, *chlamys*, covering).—Flowers have only a single envelope (perianth) or none.

Another Sub-class not mentioned in this edition of "Johns" is named GYMNOSPERMÆ (Greek, *gymnos* = naked, and *sperma* = a seed). No perianth, no ovary or styles; ovules and seeds seemingly naked.

CLASS II. MONOCOTYLEDONS.—One cotyledon. Leaves generally parallel-veined. Stem growing by matter added from within, whereas Dicotyledons increase their stems by new matter added just under the bark.

SUB-CLASS I. PETALOIDÆ.—Flowers possess petals.

SUB-CLASS II. GLUMACEÆ.—Flowers possess *glumes*, which are chaffy scales. Grasses belong to this Sub-class.

Each Sub-class is divided into *Natural Orders.* These Orders are composed of *genera,* or families; the genera are composed of *species,* or kinds; and there are sometimes *varieties* of species.

When you have a flowering plant you wish to identify, the first matter to be decided is whether it is a Dicotyledon or a Monocotyledon. When you have settled this point, you go on to ascertain which Sub-class it belongs to. When you know the Sub-class, you have to find the Natural Order, then the genus, and finally the species, and perhaps the variety.

Here is a plant bearing flowers, and we will suppose we do not know its name. Without doubt it is a Dicotyledon; its leaves are net-veined, and it has all the appearance of its class. Now, to what Sub-class does it belong? See, it has both calyx and corolla, so it must belong to either the Thalamifloræ, Calycifloræ, or Corollifloræ. Look at the petals; they can be separated one from another without tearing any of them; they are *distinct.* Do the petals and stamens grow separately from the sepals forming the calyx? They do. Where do the stamens spring from? Why, they rise from below the ovary. There can be no doubt about it: this plant belongs to the Sub-class Thalamifloræ.

So far so good. Now we have to decide the Natural Order, an operation which will take some time and careful thought. We look at "Johns," p. 2, and read the description of the Natural Order Ranunculaceæ. Plants of this Order have pistils of several carpels, as in the Buttercup. Our plant has one ovary, so it cannot belong to the Order

Ranunculaceæ. On p. 10 we find particulars of the Order Berberidaceæ, but our plant does not answer to them. We go on and on through the Natural Orders until we come to Caryophyllaceæ on p. 38. At last we have found an Order which our plant fits; but we immediately discover that this Order is subdivided into two *Sub-orders*. Sub-order Sileneæ has sepals connected into a tube. The sepals of our plant answer this requirement, so we conclude that it belongs to Sileneæ. We are getting on very well, but have yet to decide the genus and species. We go through the details of the genera on p. 38 until we get to *Lychnis;* we stop at *Lychnis*, for we are satisfied our plant belongs to that genus—it answers to the description in all points. Now we turn over the pages of "Johns" until we come to the list of species belonging to the genus *Lychnis*. We find the list on p. 42. Our plant must be one of the six species described. We decide that it is not *Lychnis Flos-Cuculi* (Ragged Robin) (Plate 47, *a*) because it has not deeply four-cleft petals. It cannot be *L. vespertina*, because its flowers are rose-coloured, and open during the day. But—yes, it must be *L. diurna* (Red Campion), for it answers the description exactly.

So, after some pleasant toil, in the course of which we have picked up quite a lot of information, we have run our plant to earth—we have identified it. It is no less than the lovely Red Campion that flourishes in the hedgerows and helps to make them beautiful all the summer through. You will find a photograph of our friend on Plate 18.

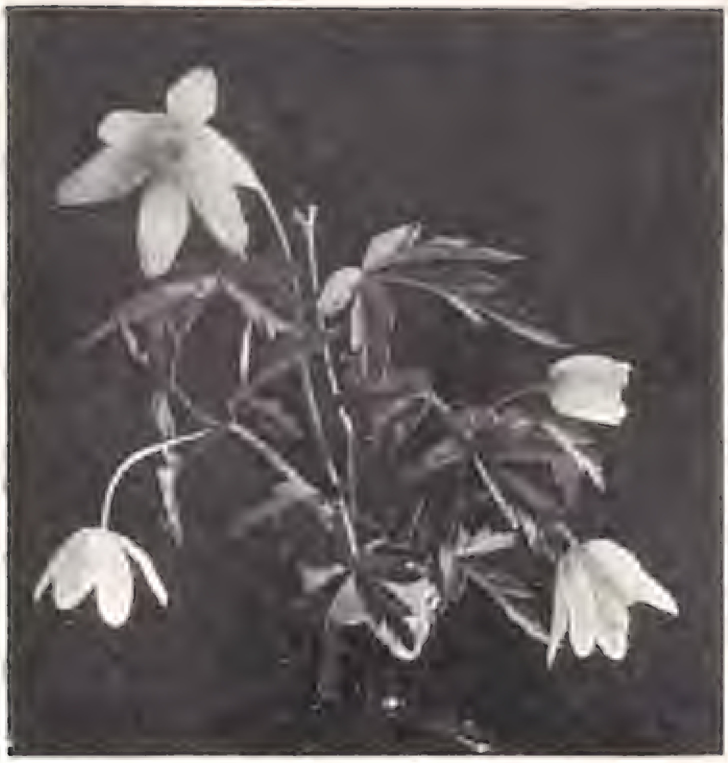
There are four more plants here for us to identify.

This one evidently belongs to Sub-class Calycifloræ. We scan the Natural Orders of this Sub-class until we reach Onagraceæ ("Johns," p. 92). Now we have determined the Order, we ought not to have much difficulty in settling the species, for there are but five genera, and the greatest number of species are included in the genus *Epilobium*. There is no Sub-order in this case. Yes, our plant is an *Epilobium*; it answers splendidly to the requirements of that genus; and the second species that is described is the one we are looking for. The plant we hold in our hands is *Epilobium hirsutum*, the Great Hairy Willow Herb, or Codlins-and-Cream (see photograph on Plate 20, *a*).

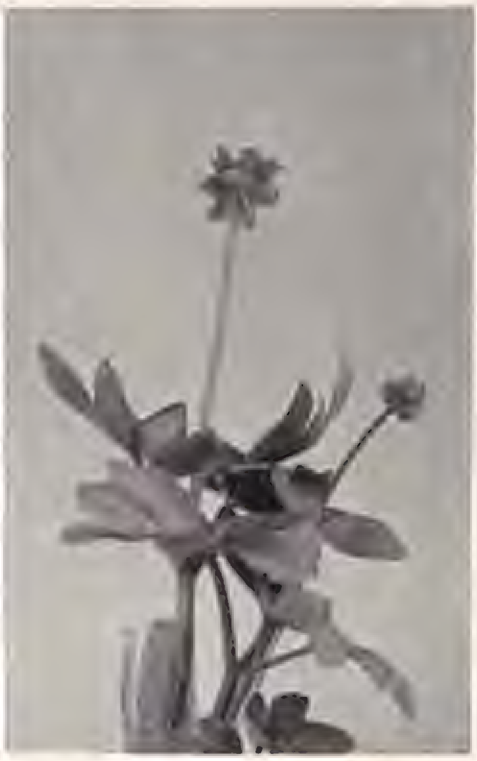
The Buck Bean (*Menyanthes trifoliata*), illustrated on Plate 20, *b*, is another of the plants I have gathered. It represents the Sub-class Corollifloræ and the Natural Order Gentianaceæ. Did you ever see a more exquisite flower? Its ternate leaves are somewhat like those of a Broad Bean, but its flowers, to my mind, are the very acme of beauty. See the delicate white fringe on the petals! What, indeed, could be lovelier! But you should have seen the big patch of these flowers on the marshy ground from whence I brought this specimen: it would have given you some idea of how Nature beautifies apparently waste places, and makes them sweet. The Buck Bean is decidedly a flower to hunt for, and once you make acquaintance with it in its natural haunts, you are not likely to forget it. Some people call this flower the Bog Bean, and it is a good variation of its name, for it grows in and beautifies boggy ground.

To represent the Sub-class Monochlamydeæ I have obtained some Spotted Persicaria (*Polygonum Persicaria*) (see Plate 20, *c*). It belongs to the Natural Order Polygonaceæ. Unless you have very keen eyes, you will need a hand magnifier to examine it with. Notice the numerous spikes of crowded tiny pink flowers. The perianth is cleft into fine deeply-cut lobes. There are six stamens. The leaves are lanceolate, and they appear to be bruised or stained near the centre. One might say that the leaves have blotches of deep green or purple on a lighter green background. At the points where the leaves join the stem you will observe some membranous stipules, which are stretched across the angles made by the petioles with the stem. This form of stipule is called an "ochrea" (Latin, *ochrea* = a legging). The magnifier shows that the ochreæ of Persicaria are fringed with bristles. This seems a small detail to notice, but it is one of many that are sometimes of great importance in identifying species. The next species in the genus *Polygonum*, the Pale-flowered Persicaria, has similar ochreæ, but the lower ones are not fringed. The Spotted Persicaria is a common weed in cultivated ground and waste places, but its commonness does not detract from its beauty. You have but to look through a magnifier into the heart of its tiny flowers to realize how lovely they are. When we are staying in the country we often use this plant for table decoration ; it is very effective as such.

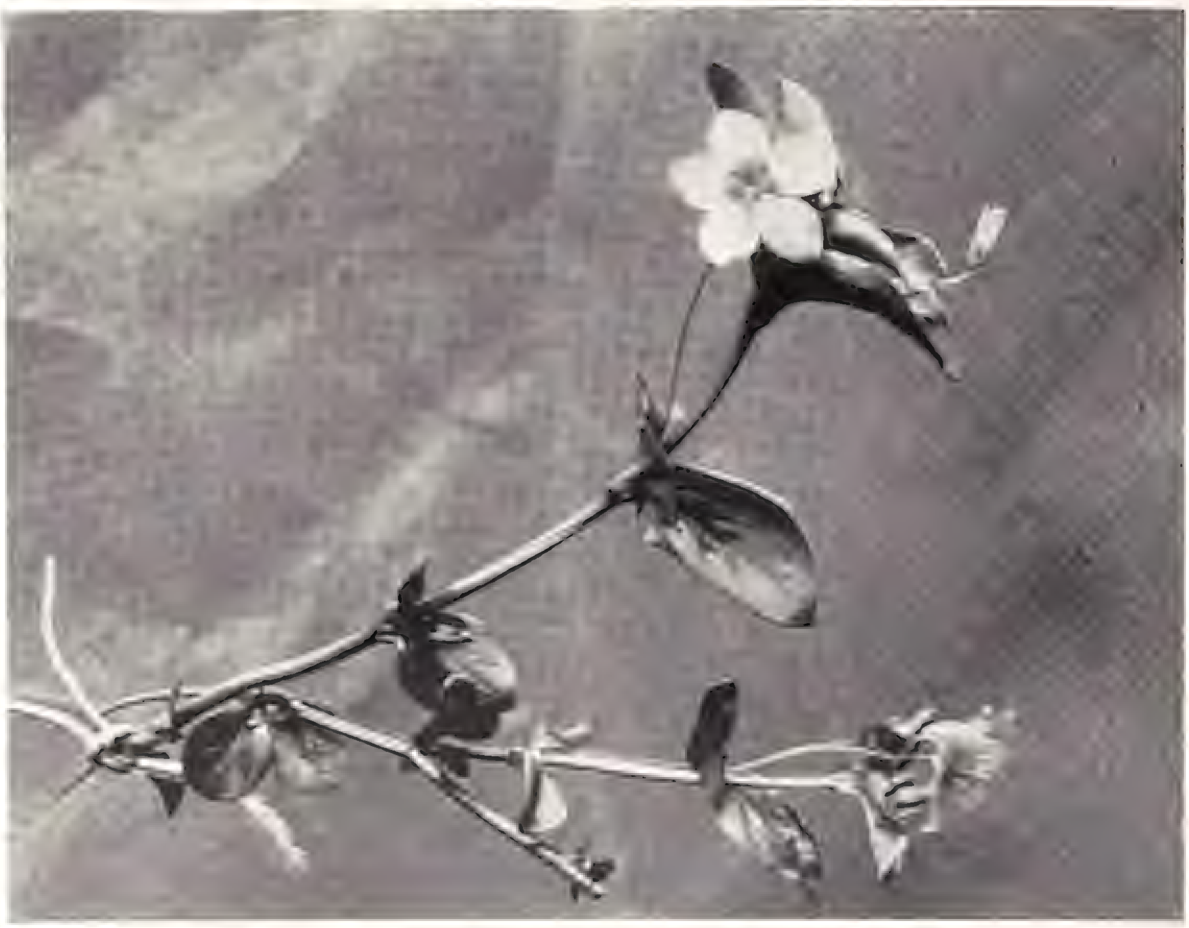
The plant we are now to examine is undoubtedly a Monocotyledon, and it must belong to the Sub-class Petaloidæ, for it has beautiful white petals



(*a*) Wood Anemone. *P.* 197.

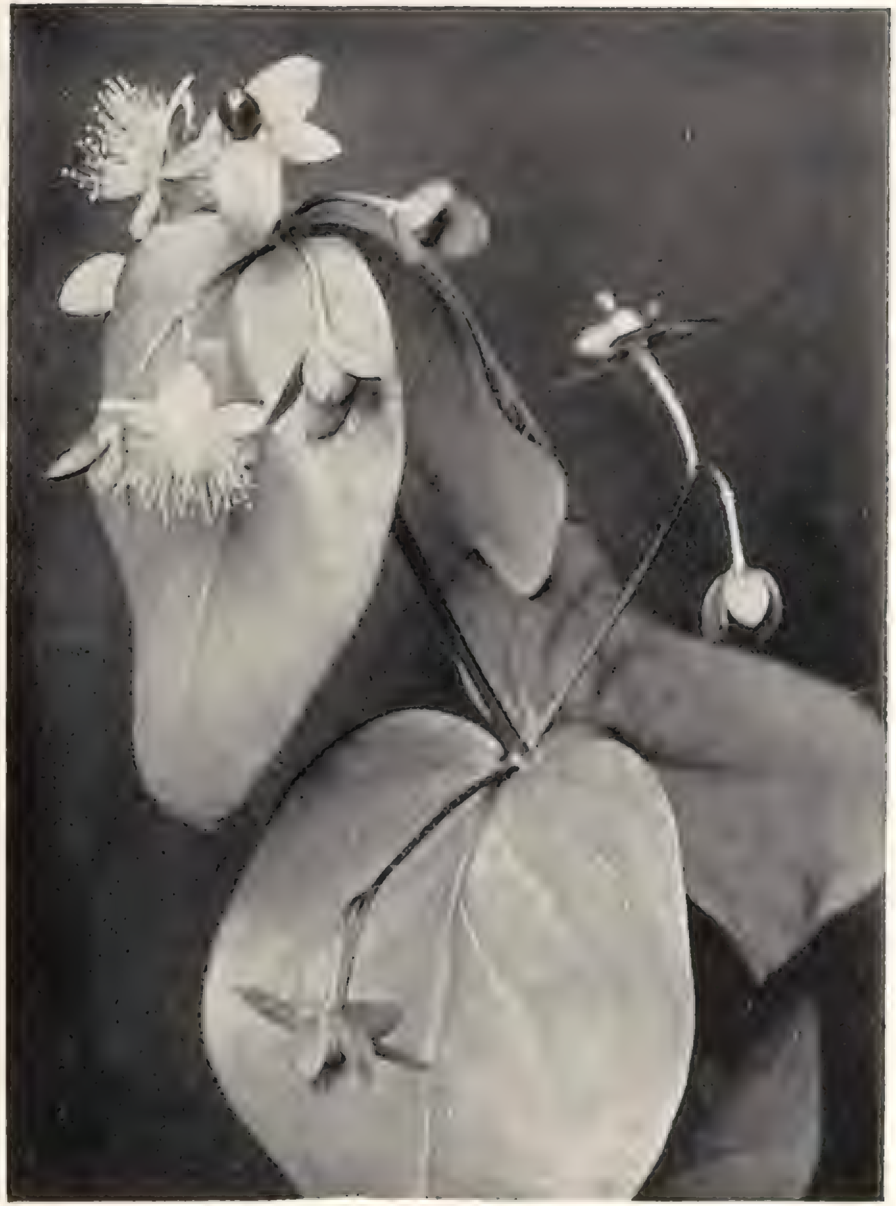


(*b*) Moschatel. *P.* 198.

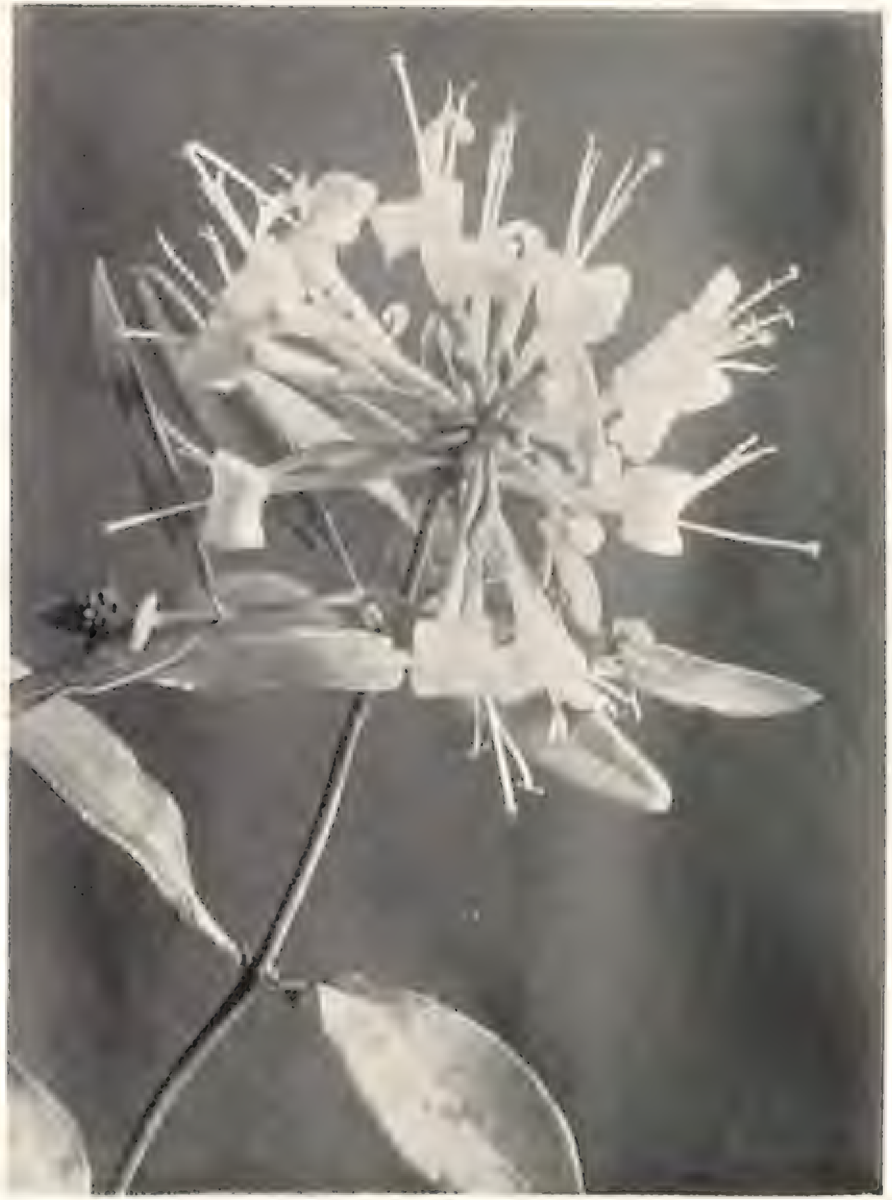


(*c*) Yellow Pimpernel. *P.* 209.

PLATE 39



(*a*) Tutsan. *P*. 197.



(*b*) Honeysuckle. *P*. 199.

and is not a bit like a grass or a sedge. Notice the parallel-veined leaves. What I have called petals are really the six segments of the perianth. The flowers grow in umbels, and you will see that before they break out—that is, when they are in the bud stage—they are enclosed in a green kind of envelope, called the *spatha.* Open one of these budlike arrangements; see the young flowers exquisitely folded within the spatha. Their flower-stalks, or pedicels, are coiled up in a wonderful way. When the spatha is burst open, the pedicels will straighten themselves out and hold up the flowers just as you see them doing in this other specimen. Bruise this leaf and then smell it. You have no difficulty in distinguishing the smell of onions. This plant is the Broad-leaved Garlic or Ramsons (*Allium ursinum*); it is a lily, and belongs to the Natural Order Liliaceæ. Don't confuse the Broad-leaved Garlic with the common Garlic Mustard, or Sauce Alone (*Alliaria officinalis*). The last-named plant grows in hedge-banks and open places in woods; it is a Dicotyledon, and of the Natural Order Cruciferæ. It also smells of garlic when bruised. The Broad-leaved Garlic sometimes grows in great profusion in damp woods and on moist hedge-banks. Its pure white flowers are very effective, but they soon droop when gathered, and we do not court them on account of their disagreeable smell (see photo on Plate 17, *b*).

I shall now bring this chapter to a rapid conclusion. I have told you how to proceed in the identification of flowers, and must leave you to follow my suggestions. I may as well warn you that you will not always find your work such plain sailing as I seem to indicate. But you must persevere. It is in the ferreting out of plant-names that you will become familiar with botanical terms. You can never remember plants so well when you get a friend to tell you what they are. What you find out for yourselves you *know*; what you are told you are apt to forget. Besides, the work of identification is a real pleasure. I like to find an unfamiliar species, and find out from my "Flora" what it is. An evening spent in identification after an afternoon's collecting is one of the keenest delights I have experienced.

Perhaps I ought to tell you what you may already have noticed. The Latin names of plants, which you should not fail to learn, are always written with the generic name first, and the specific name second. Example: *Epilobium hirsutum*; *Epilobium* is the genus, *hirsutum* is the species. The generic name starts with a capital letter; the specific always starts with a small letter, unless it is the Latinized form of a proper name.

A final word, as the preacher says. Aim at knowing the plants of your own district; know them thoroughly. Keep a diary of the dates on which they first appear in each year. Do all you can to prevent the wanton destruction of plant-life. Notice how plants group themselves; you will find certain kinds haunt particular situations. Catalogue the plants of the moorlands, the flowers of the fields and hedgerows, as well as the floral occupants of mountain, marsh, and riverside. Remember that a common, insignificant weed is botanically as interesting as the showiest of flowers.

CHAPTER VII

A RAMBLE IN MAY

LET me see! To-day is the 28th of May. The sun is shining gloriously; there are a few fleecy clouds in the sky, the light is brilliant, and there is every prospect of good weather. I think we ought to go for a ramble and see Mother Nature at work. I have no doubt we shall find plenty of food for thought. The birds are as busy as they can be. I awoke early this morning to hear a glorious chorus; a flood of song seemed to stream through my windows along with the sunshine and the sweet fragrance of the garden. The flowers are every day increasing in numbers, and there should be plenty of insects to entertain and instruct us.

We must see that we are properly equipped for our day's work. We shall walk a fair distance, not keeping to the beaten track all the way, so we had better wear some old, easy shoes; and as we may have to clamber over rocks, and even lie on the ground in stalking some animals, it will be wise to put on old clothes. It is a real nuisance to have to think about one's clothes when one is out for a day's Nature-work; I am sure a fastidious dude could not be a naturalist. It will probably be evening before we get home, so we must take some sandwiches, just to stay the pangs of hunger, but not to spoil our appetites for a good meal when we return. I am going to take my camera and plenty of plates, for I am sure there will be some interesting pictures to get—pictures which will be accurate records of a goodly number of our observations. Victor here will carry my big vasculum; Howard will take a haversack. But we shall need some pill-boxes as well, and I will slip that little case of corked glass tubes into my breast-pocket. That geological hammer is a fair weight, but we must take it. See, I have a loop on the back of my waistcoat, into which I slip the handle. There, it rests quite comfortably, and is hidden from view by my coat. Now I think we are ready.

Perhaps some people think that such an equipment for the field must be a terrible burden, and they may say that, if Nature-study means carrying so much apparatus about on their rambles, they are not going to be bothered with it. That is the kind of people who need carrying everywhere they go. If they have to take a journey of a couple of hundred yards, they must be hauled in a street-car or a motor. Needless to say, they will never be naturalists; they are not built that way. Then, the naturalist sets out to *take* records, not to break them. He does not walk for a wager; he is never in a hurry, never impatient; and as for the load, *that* is carried by his enthusiasm. Your naturalist is a self-reliant, independent, and manly mortal; you find him out in all weathers, facing sunshine or storm; you see him drenched to the skin, yet cheerful; perspiring under a hot sun and a heavy load, yet rejoicing on his way.

Now, boys, let's be off. Before we get on to the road, I want to see what is going on in that laurel-bush by the gate. For several days I have noticed a pair of Hedge Sparrows flitting about that bush in a very business-like manner; I suspect they have a nest in it. Gently! Don't disturb or worry the birds any more than you can help. I like the idea of birds nesting in my garden. I think they pay me a great compliment by doing so, and I offer them all the kindness and hospitality I can.

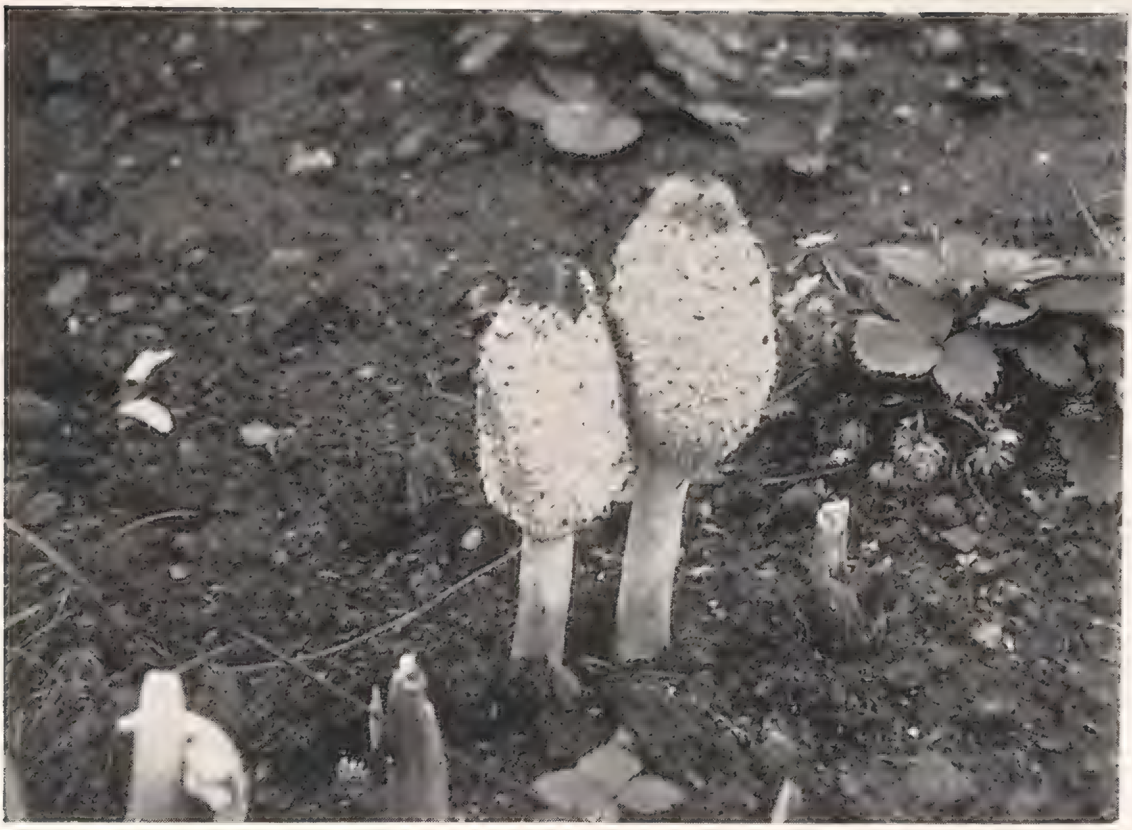
Yes, it is as I expected. Here is a neat little nest, built of moss, some twigs and dry grass, with a lovely lining of hair and some feathers. I never see a bird's-nest without marvelling at the ingenuity and industry of its builders. Think of the quantity of material in the nest we now see, and of how it has been gathered and carried bit by bit. Observe the cleverness and neatness of this "home made without hands." The birds must have been busy from dawn to past sunset for several days, working hard without a grumble, and in eager anticipation of the family which is to come by-and-by. There are four eggs of a delicate blue colour; they seem to have caught the azure of the sky. I always think the little blue eggs of the Hedge Sparrow are as lovely as any I have seen.

But we must move away from the nest, for the birds are uneasy, and I should not like them to desert their eggs. They may lay one or two more, and in a short time there should be a family of young birds. Now that the old birds think we are at a safe distance, they are back at the bush. Look at them through this field-glass. Both male and female are alike in plumage. Their backs and wings are a warm brown streaked with a brown that is almost black at first sight; their throats, cheeks, and breasts are of a colour between a slate and a grey, and they are almost 5½ inches in length. I am sure you will have often noted their little song; you may hear it, and be thankful for its cheeriness, in the midst of winter, when bird songs are scarce. I ought to tell you that this bird is not a true sparrow; it is a near relation of the Robins. I expect we shall go on calling the bird a Hedge Sparrow, for that is the almost universal practice, but its proper name is the Hedge Accentor. I always connect the name "Accentor" with the song of the bird, which seems to me to sing in accents, jerking up and down and here and there on the scale in a very peculiar fashion. The scientific name of the bird is *Accentor modularis.*

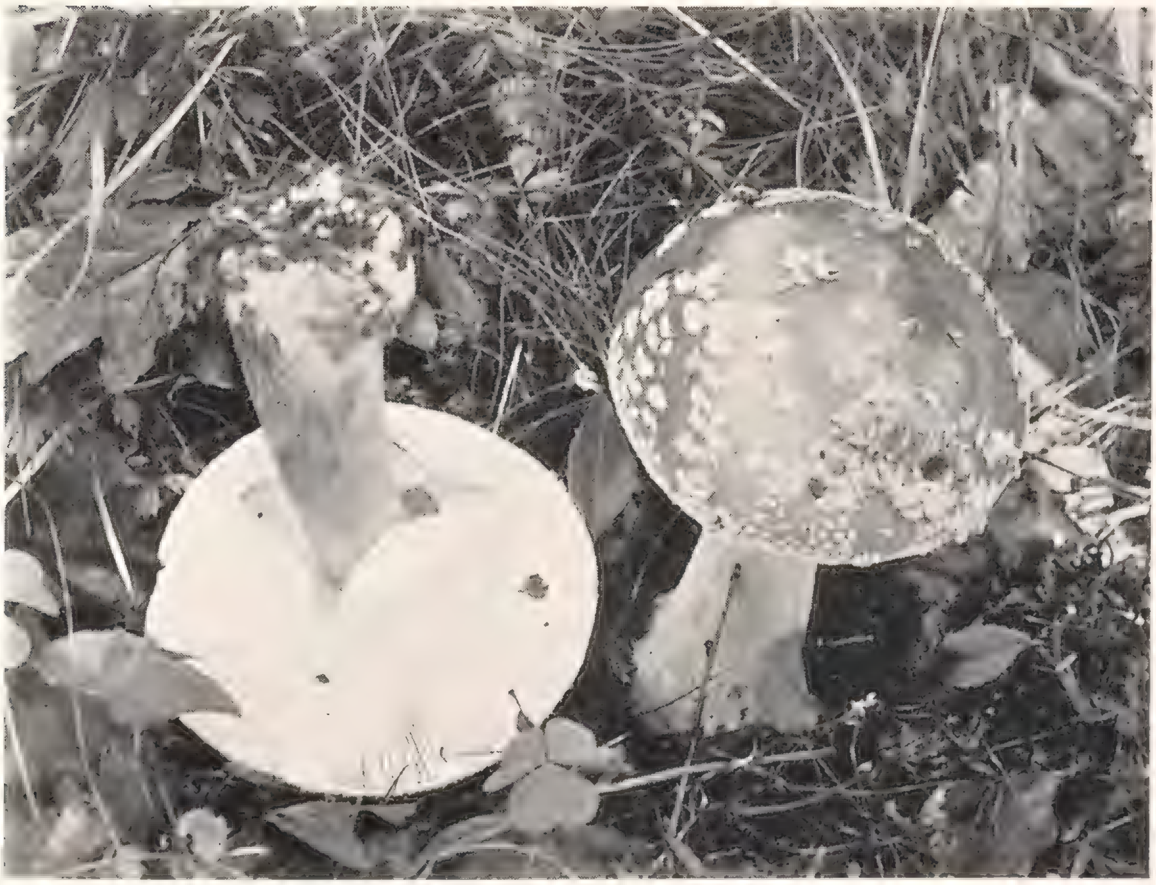
We'll make our way along the lane to the quarry. The hedges are a glorious green just now; they look sweet and wholesome in their new foliage, which has not yet got dimmed and dingy with dust. The hedge-banks are bright with flowers. Here is a big patch of White Dead Nettle (*Lamium album*). This plant is so common in our district that we are apt to pass it by without remark, but there are parts of the country where it is scarce. I have hunted for it whole days in the West of Scotland without finding it. It is really a very sweet plant, and one that merits more notice than is often given to it. As its name implies, it is a "dead nettle." It has no stings. Its young leaves make good eating, like those of the Stinging Nettle; but the latter protects itself by its stinging hairs, which, as you know, can make us feel very uncomfortable. Cattle will not touch the Stinging Nettle on account of its stings. But why do they not eat up the tender White Dead Nettle, which has no stings? Well, you see, the Dead Nettle has leaves very like those of the Stinging Nettle, and cattle are deceived by it. They know that some nettles sting, and so they avoid all nettle-like plants. You can see, too, that the Dead Nettles grow very near to, and often amongst, Stinging Nettles. Don't you think it a clever arrangement? It is just like a traveller disguising himself in the clothing of hostile peoples, in order that he may be mistaken for one of themselves, and so have his life preserved.

We have some five species of Dead Nettles in our flora. You will know that common weed, the Red Dead Nettle (*Lamium purpureum*) very well; it comes up far too persistently in the gardens. The leaves are all more or less nettle-like. All these plants belong to the Sub-class Corollifloræ and the Natural Order Labiatæ (Latin, *labium* = a lip). The corollas of the Labiate family are tubelike at the base, but in their upper and more conspicuous portions they are split into two lips, and have the appearance of a wide-open mouth. The top lip, as you can see from the flower of the White Dead Nettle, forms a little helmet-like protection to the stamens, while the lower lip makes a good step or platform for insect-visitors who are eager to secure honey. Take one of these flowers and suck it between your lips ; do you not notice the sweet taste ? When the insect-visitor gets its honey, it also gets dusted with pollen, which it carries away to another flower, and, in searching for honey in it, some of the pollen reaches the stigma, and in due time fertilizes the ovules. The Labiate family are easily recognized by their peculiar flowers and their square stems. Many of the species are very fragrant. Lavender yields a fine perfume, and the various species of Mint are members of the Order. Let me point out that the Dead Nettles are not near relations of the Stinging Nettle. This plant belongs to a different Sub-class—Monochlamydeæ—and the Order Urticaceæ.

Two species of Stinging Nettle are common with us: the first is the Great Nettle (*Urtica dioica*), which is too well known to need a full description, although I ought to ask you to notice its long, branched clusters of small flowers ; the second is the Lesser Stinging Nettle (*Urtica urens*), which is a smaller plant, having shorter leaves and short flower clusters. Its sting, however, is no less irritating than that of its bigger brother. The name "Urtica" comes from the Latin *uro* = to burn, and if you have ever been stung by nettles, I am sure you will think it is a good name. I was once pitched by a donkey into a big clump of nettles, and for a few hours I thought my face and hands were on fire. Ammonia kills a nettle-sting, and it is claimed that the juice of the common dock is also an antidote. I have tried it myself, and think there is something in the claim. Some East Indian species of nettles have most vicious stinging powers, and there is a Java species

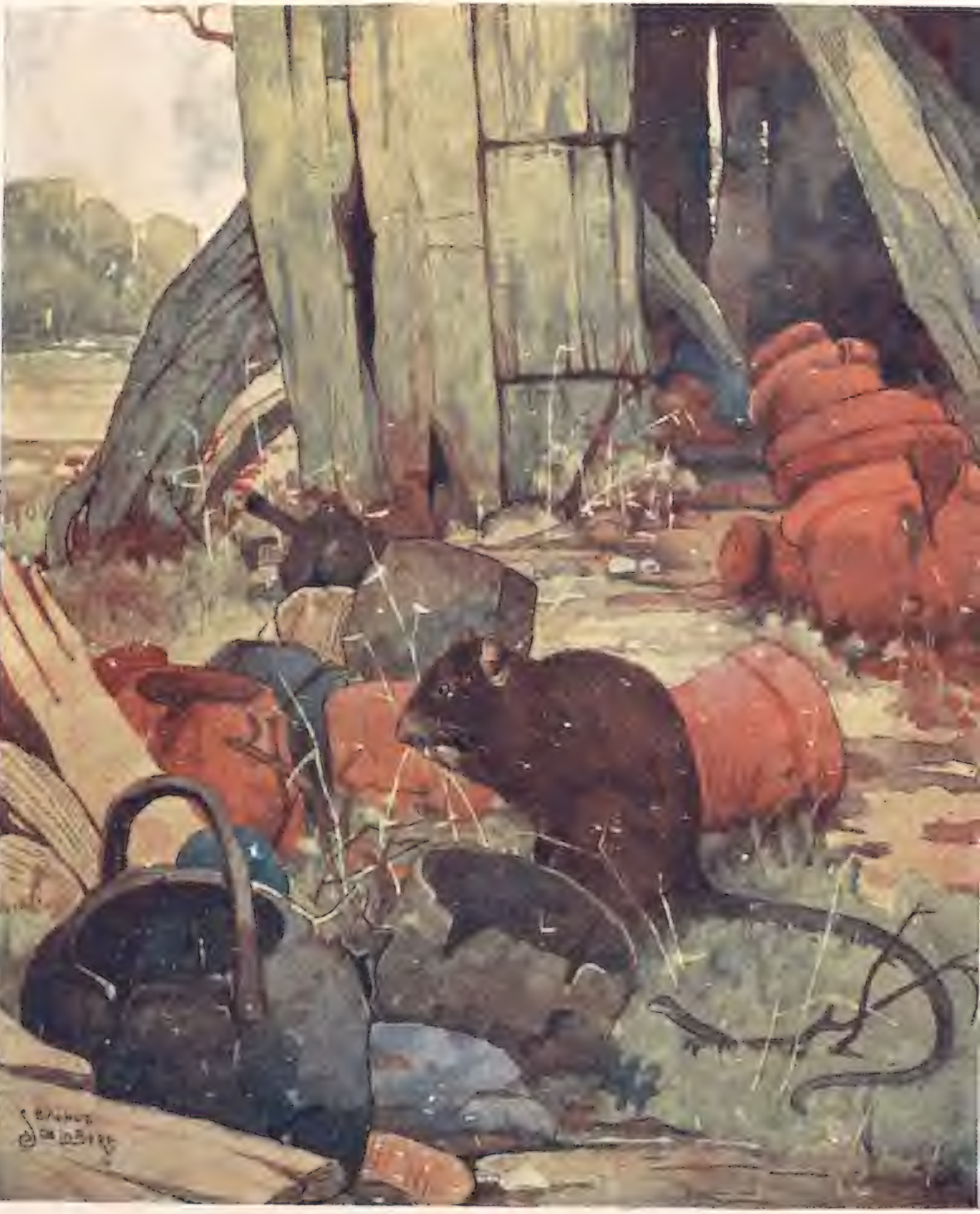


(*a*) Maned Agaric, or Shaggy Caps. *P.* 201.



(*b*) Warty Caps. *P.* 201.

PLATE 41



Common Rat. *See page* 178.

which causes suffering for many months, and has been said even to cause death. Our country has "a mild and variable climate," say the geography books, and emphasis should be laid upon the word *variable*; but we may thank our stars that we have no such vicious animals or plants as are found in countries where the sun blazes more steadily than with us.

We are right amongst the Labiates this morning. I see the Ground Ivy (*Nepeta glechoma*) is in great profusion. Notice its trailing stems and its bright purplish-blue flowers, which grow in threes from the axils of the leaves. If I had not seen the blue of the Hedge Sparrow's eggs quite recently, I should probably have said there never was such a blue as that of the Ground Ivy. It is a humble flower, but, like humble folk, it improves on close acquaintance. Old-fashioned folk say the dried leaves of this plant make a healthy tea; probably there is something in their statement, but I have not tested it practically, so cannot give you my testimony on the point. Then, here are some young plants of the Hedge Wound-wort (*Stachys sylvatica*). They have leaves, but not flowers. The latter do not usually appear until July. But you may know the plant quite well without its flowers; it has heart-shaped, crenate, stalked leaves, and if you bruise one of the plants you will at once detect an offensive smell, which has been likened to that of festering wounds. I think I have seen it stated somewhere that this plant was once used as a healing balm for wounds. You will say the remedy was surely worse than the evil. Still another Labiate—

this time the Bugle (*Ajuga reptans*). This plant frequents woods and damp meadows, but here are a few spikes of it in a moist, mossy patch on the laneside. Blue labiate flowers, mark you, growing in circles, tier above tier round the stalks. And it also has runners (scions) springing from the crown of the roots and creeping on the ground. This plant increases its numbers by runners as well as by seed. Fancy Victor here sending a long runner out of his shoulder and growing a little Victor at the end of it! Well, big Bugle grows little Bugles that way, and it can thus do what it is impossible for men to achieve. I love the Bugle because it is one of the early spring flowers, and shows its lovely tint of blue in welcome relief of the monotony of yellow that prevails early in the year.

What's that you say? A butterfly? Oh yes; I see two. One is a Small White (*Pieris rapæ*), quite common, but no less interesting on that account. That is the lady who lays her eggs on cabbages, and the caterpillars which emerge from the eggs literally eat cabbage until they are too big for their skins. But they are quite equal to the emergency; they throw off their tight skins, and appear in clothes more suited to their size. Quite a good way of loosening the belt, you will declare. The time comes when the caterpillars (*larvæ*, you should call them), which are green, with a yellow line along the back and dotted yellow lines on the sides, cease to feed, and turn into chrysalides, or *pupæ*. Then the butterflies in due course emerge from the pupæ, dry their wings, and stretch them for flight. I have heard boys say that Small White butterflies are young Large Whites, but that is a mistake. Large Whites are a bigger species, and butterflies do not grow.

The other butterfly, now over the hedge, is a Brimstone (*Gonepteryx Rhamni*), and a male. I think the Brimstone is one of the loveliest of the upwards of seventy species of British butterflies. The male is of a beautiful sulphur colour, with a deep orange spot on each of his four wings. The female has wings much less conspicuously coloured. They are greenish-white, merging into a yellowish tint at the extremities of the wings. The specimen we have seen must have spent the winter in some snug place of concealment. To be correct in our language, we should say it has *hibernated*. Brimstones "come out" in autumn; they have but one brood in the year, and any that are seen in spring have survived the winter. Hibernated specimens usually show marks of wear and tear; we get the most perfect specimens out of the new autumn brood. The caterpillar of the Brimstone feeds on the Buckthorn, one species of which (*Rhamnus frangula*) grows well in this neighbourhood.

We will make for the pond at the corner of the lane, and then cross the field to the quarry; but I must ask you to notice one more plant of the hedge-bank—the Garlic Mustard (see p. 145). It grows here in profusion; its flowers are quite small in comparison with those of the Broad-leaved Garlic which I showed you the other day, and it has not the appearance, the structure, or the habits of a lily.

Ah! we have disturbed a Blackbird (*Turdus* *merula*). Hear what a screaming cackle it makes! Its nest will be in the hedge hereabouts, for the bird flew out of it quite near us. Is that it? No; that's an old nest in ruins. Be careful of the thorns! I see it now, and can reach it quite easily. Four eggs, as warm as a toast! I'll expose a plate on it. It's not easy to get at, but I think I'll manage it all right. Photographing bird's-nests in their actual sites is not exactly plain-sailing; there's no studio work about it. We have to contrive all sorts of ways of getting at the nest with the eye of the lens. We mustn't be long about our work, for the birds are anxious. One of you set up the tripod, and you, Howard, get the camera ready. I'll cut some sticks to lengthen the tripod legs with.

Now I tie the sticks on to the legs of the tripod, and the camera is raised to a suitable height. With careful tilting I can get the nest into focus. But how am I to reach the camera? Here, Howard, you are a fair photographer; you get on my shoulders and work away. What! can't see wood for trees? Too many thorny branches in the way! We must tie them back. Now, how's that? All right? Then get a sharp focus, stop down your lens to a small aperture, so as to get definition. Here's the dark slide. Careful, now, or the camera will tumble. Five seconds' exposure! Done? That's good! We'll move on now, in the hope that our picture will turn out A1.

Dear me! What contrivances Nature photographers have to invent! I declare my shoulders are quite sore. But that effort was not half so bad as one I made when I was on holiday in Arran.

I was anxious to get a picture of that lovely shrub, the Tutsan (*Hypericum Androsœmum*). I came across a beautiful specimen growing at the side of a rapid stream, the bed of which was strewn with boulders. I stood high and dry on a boulder, set my camera legs in the stream, and got my plant focussed. Just when I was going to put in the dark slide the stream upset the camera. I made a dart for it, and before I realized what had happened, I was in a hole of the stream, nearly up to my waist! However, I had my revenge. I stood in the cold water—it was very, very cold—and got my picture. A little wetting does one no harm so long as the blood is kept in circulation by active exercise. I walked a couple of hours in my wet condition, and experienced no ill-effects.

Now we are at the pond. How luxuriantly the hedge grows in the background, and how the Alders almost kiss the water! The Hawthorn (*Cratœgus Oxyacantha*), which, by the way, belongs to the Rose family, is in glorious bloom, and the air is laden with its fragrance.

I have caught both Pike and Perch in this pond. The Pike, you know, has the reputation of being the fresh-water shark, and I'm sure he justifies his reputation. All's fish that comes into his net! He will swallow tadpoles, fish, young waterhens, voles, and even young ducks. He has a habit of remaining apparently motionless among the weeds, but when he spies an attractive morsel he is after it like a shot. I think the Perch is the most beautiful of our fresh-water fish; he is dressed in a lovely combination of colours—red fins, deep green back, shading into a greenish-yellow on the sides, striped transversely with broad dark bands. He has a prickly fin on his back, and anglers have to be careful how they handle him, or they may get a sharp prick.

There are Tadpoles here—hundreds, thousands of them. You know that Tadpoles do not always remain Tadpoles; they are really the larval stages of some of our Amphibians. Some Tadpoles develop into Frogs, but it is a mistake to think that Frogs are the only animals that were once Tadpoles. There are Tadpoles that become Toads, and others turn into Newts. It is difficult to distinguish the different kinds of Tadpoles in their earlier stages; that of the Toad is darker than that of the Frog, while the Newt Tadpole does not lose its tail.

My particular object in visiting the pond to-day is to get my little glass tubes filled with some material for examination under the microscope when we get home. See that red patch in the water just in front of us. That is due to a host of Water Fleas. I'll tie a tube on to the end of this stick, and secure a supply of the lively gentry. The red patch has disappeared; that plunge of my tube gave the Fleas a fright, and they have scattered. But I've got a few of them all right. Notice their jerky motion in the tube. They will give us some entertainment at home this evening.

Now I'm going to secure a little Duckweed from the surface of the water, and I shall fill a tube with some of that green threadlike stuff. I must also get some of this discoloured mud in another tube, and I will fill two or three more with water, on the chance of getting something worth having in the water. We shall not examine our catch now ; we shall have more time for such work at home, and, besides, we shall need the help of the microscope.

Hullo ! there's a Moorhen (*Gallinula chloropus*). See it in the water right across the pond, not far from the bank and behind the rushes. The Moorhen seems to like small sheets of water like this, while the Coots (*Fulica atra*), a number of which may be seen on the big dam about a mile away, prefer bigger expanses. You know the difference between these two water-birds. The Moorhen is about 12 or 13 inches long, while the length of the Coot is something like 18 inches. The Moorhen's bill is yellow with a red base ; the Coot has a bald, white patch on the forehead, and its bill is a pale lavender colour, with a tinge of pink.

Before we leave the pond we must notice a few plants that grow hereabouts. That white flower growing in the water is the Water Crowfoot (*Ranunculus aquatalis*). It belongs to the Buttercup family. Just reach a specimen with this stick and observe a peculiarity in connection with its leaves. It has leaves which grow under water that you will see are cut up into hairlike segments, whereas the upper floating leaves are kidney-shaped, and not cut. It seems that the submerged leaves are cut so as not to offer too much resistance to currents of water. You see, a strong stream of water might drag the plant from its moorings were its leaves uncut. The River Crowfoot (*Ranunculus fluitans*) has its submerged leaves much more finely cut, and its hairlike segments are longer than those of the Water Crowfoot. It has adapted itself to the more powerful stream. How wonderfully all things in Nature are suited to the situations in which they exist!

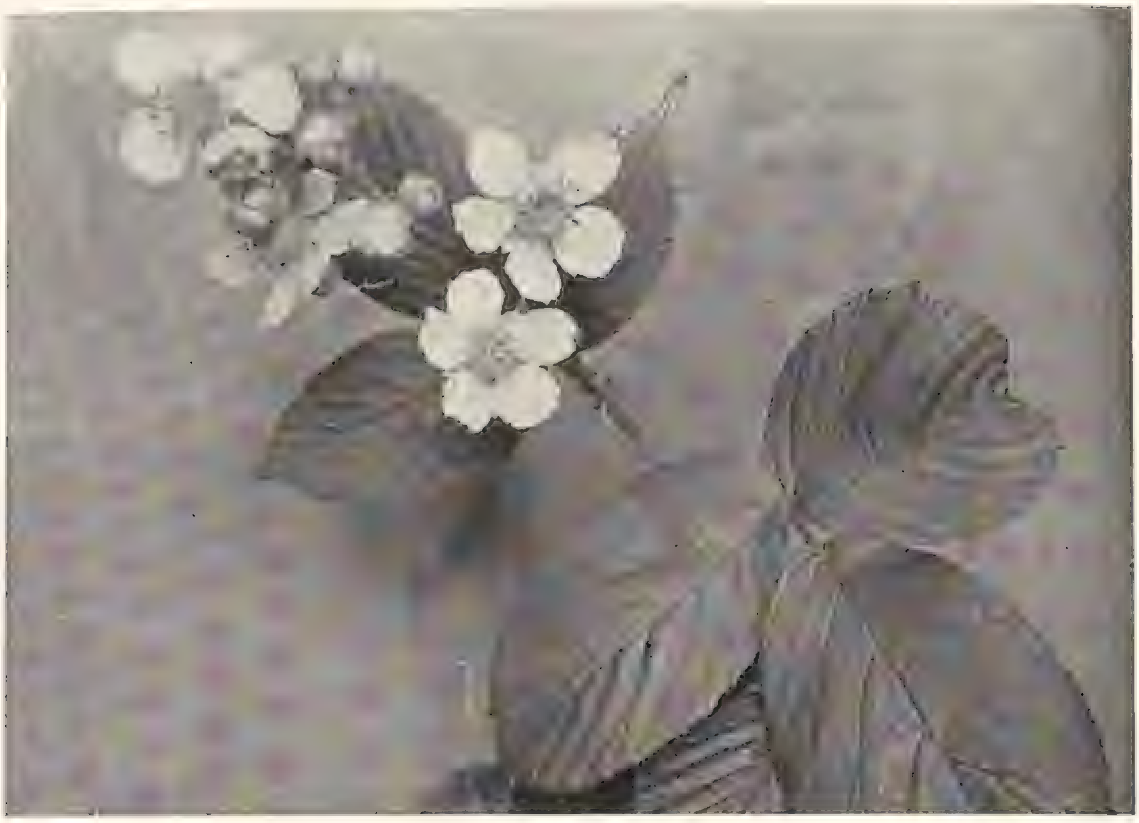
There is plenty of the Lesser Spearwort (*Ranunculus flammula*) about, but I do not see any of its flowers. There are some buds, however, and some flowers should be out in a week or so. This plant has rather small Buttercup-like flowers. Its leaves, observe, are shaped like long lances; they are very different from those of the ordinary Buttercups.

Then here is the Marsh Marigold (*Caltha palustris*) in great profusion. What lovely big golden flowers! Well might some people call them "Kingcups." This plant is another member of the Ranunuculus family. Its leaves at present are comparatively small, and they are not divided; later in the year they will grow much larger. Why should this be? Well, the flower is all-important just now; it wants sun and air, and the visits of insects; big leaves would be in the way, but later on, when the flowers have done their work, the leaves can grow freely without injuring the prospects of the flowers. Indeed, the leaves are very busy after the flowering season; they transform carbonic acid out of the atmosphere into food, and store it away for next year's growth.

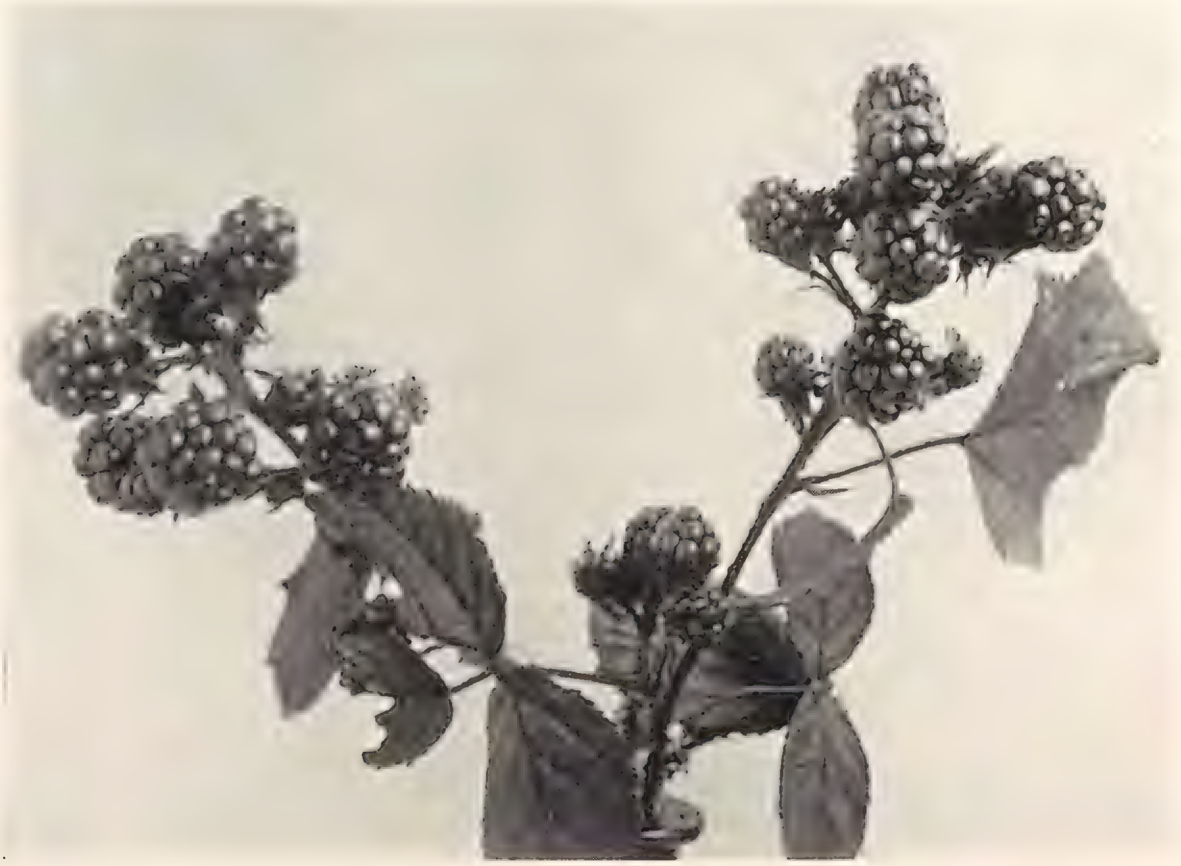
Another plant here is a common colonist of damp ground—the Cuckoo Flower, or Milkmaid (*Cardamine pratensis*). Its stem, though slender, is rather tall; it grows in a slightly zigzag way, and reaches a height of from one to two feet. The leaves are pinnate. The flower has four petals, which are

PLATE 42

SQUIRREL. *See page* 193.



(*a*) Bramble (flower). *P.* 180.



(*b*) Bramble (fruit). *P.* 180.

sometimes white, but more often of a pale purple or lilac hue. Observe the crosslike arrangement of the petals. This plant is one of the Cruciferæ (cross-bearers). In wet seasons small bulbs are often formed at the base of the stem.

We will not linger at the pond; we must make for the quarry. But I see some white in the hedge-bank yonder, and we must see what it means. As I thought, we are now among the umbelliferous plants, which bear their flowers in an umbrella-like fashion. This is the Wild Beaked Parsley (*Anthriscus sylvestris*), one of the earliest of our umbelliferous flowers. The stem is branched and the branches spread out widely; there is a slight swelling where the branches join the stems. The leaves are tripinnate, and the umbels, which droop in the early life of the flowers, have from eight to ten rays.

From whence comes that sweet smell? The sun is drawing out the fragrance of the Sweet Cicely (*Myrrhis odorata*), a clump of which is growing hard by. The umbelliferous plants are like the Hawkweeds in one respect only: the amateur botanist finds it difficult to distinguish the various species. However, there is little difficulty in knowing Sweet Cicely, which well deserves its name. It has a fragrance akin to that of Aniseed, and its tripinnate leaves are blotched with patches of white, which might be mistaken for dust. The fruit is large, the seeds being contained in dark brown seed-vessels, about an inch long and rather podlike in appearance. These seed-vessels are very fragrant, and I am told that the aromatic oil is expressed from the fruits, and used to flavour aniseed balls, of which children seem to be very fond.

Why, there is a Thrush (*Turdus musicus*) sitting on her nest in the hedge. She has evidently been "sitting tight" all the time we have been here. I have noticed that both Blackbirds and Thrushes are not easily frightened away from their eggs. I should like to photograph the old lady just as she sits. Ah, she has flown. She does not care to be photographed. Four blue eggs, spotted with small black spots at the larger ends. If we cannot take a photo of the bird, we can at least take the eggs and nest. We must try to get it just as it is, without disturbing it in any way. You will hardly need me to point out the difference between the nests of the Blackbird and Thrush. That of the Thrush is lined inside with a kind of stucco which the bird makes out of decayed wood; whereas a Blackbird's nest has a layer of mud lined with dry grasses, and sometimes fibrous roots, with a little moss. At first sight a Thrush's nest appears to be lined with mud, and as the Blackbird's has always a lining of fibrous stuff, there is no difficulty in knowing which is which.

I have often seen reports about the mating of Blackbirds and Thrushes. I am sure, however, the two kinds of birds do not mate. The reports generally come from persons who do not realize that a female Blackbird has a dark spotted breast, and often looks like a very dark Thrush. In fact, the female Blackbird is often mistaken for a Thrush by casual observers, and it is they who issue the reports about Blackbirds and Thrushes mating. I hope you two boys will never jump to hasty conclusions. Be sure of your facts before you make statements.

I think if we were to stay within a half-dozen yards of where we are at the present moment, we should find plenty of interesting objects to occupy our attention for the rest of the day. I see three plants that we must notice. By the damp ditch there is an abundance of the Lesser Celandine (*Ranunculus ficaria*) holding up its lovely golden stars to the sun, and thriving gloriously. I thought the Celandine would be over by this time ; this must be a late patch. As the generic name indicates, this plant is one of the Ranunculus family. It loves moist situations, and begins to flower about March. You can see by its starry corolla of pointed petals that it is not a Buttercup. The number of petals varies. Here is a specimen with twelve ; this one has nine, and another there has eleven. The poet Wordsworth went into an ecstasy over the little Celandine. Hear his lines :

> " Pansies, lilies, kingcups, daisies :
> Let them live upon their praises ;
> Long as there's a sun that sets,
> Primroses will have their glory ;
> Long as there are violets,
> They will have a place in story :
> There's a flower that shall be mine,
> 'Tis the little Celandine."

The Greater Celandine (*Chelidonium majus*), which is frequently found in waste places, is not a close relation of the Lesser Celandine, and you must not put them down as big and little brothers. The

Greater Celandine belongs to the Poppy tribe. It has a nasty, poisonous juice, which, however, is said to remove warts. The flowers of this plant are yellow, and very small when compared with those of other members of the Poppy tribe. The juice is orange-coloured. I am sorry there are no specimens of this plant at hand, but I thought I would give you some idea of the difference between the two Celandines.

On the hedge-bank, pushing its way through the grass and thrusting its snow-white flowers to the fore, is the Greater Stitchwort (*Stellaria Holostea*). It has narrow, tapering leaves of a delicate green hue. Its five petals are each deeply cleft, making them appear to be ten in number. It is as lovely a flower as one could desire to see. It belongs to the Natural Order Caryophyllaceæ, is a cousin of the Campions, and a member of the Pink tribe. The Lesser Stitchwort (*Stellaria graminea*) is not nearly so conspicuous as its big brother, and it flowers later. I have seen it in excellent bloom at the end of September, although it begins to flower about June. Its petals are hardly longer than the sepals, and each petal is very deeply cleft.

Now, I wonder if either of you can point out the third flower I have in view? Yes, that is it: the little bright blue flower that is always pleasing to the eye. What do you call it, Victor? "Cat's-eye." What's your name for it, Howard? You have heard it called Bird's-eye or Speedwell? Well, you have pretty nearly hit the mark. It is the Germander Speedwell (*Veronica chamædrys*). The racemes of charming blue flowers rise from the axils of the shortly-stalked, hairy, serrated leaves. But I want you to notice a point about this plant that only botanists observe. Along the stem there are two opposite lines of hairs, which change their position at each pair of leaves, or, as the botanists say, they "alternate at each node." We have some sixteen species of Veronica, or Speedwell, in our British flora. The genus is included in the Natural Order Scrophulariaceæ, which embraces the Figworts, Foxgloves, Toadflaxes, and some other plants.

To get to the quarry we have to cross this meadow, which just now is almost white with Daisies, all holding their heads up to the sun in a most business-like way. But there are plenty of flowers other than the Daisies in the meadow. I see three kinds of Buttercups: one the Creeping Crowfoot (*Ranunculus repens*); another the Bulbous Crowfoot (*R. bulbosus*); and the third, the Upright Meadow Crowfoot (*R. acris*). The two last-named plants are rather early in their appearance, as they do not usually flower till June. Of course, this is the 28th of May, so that they are only about a week before their time. Flowers are usually fairly early in this meadow, probably because it faces the south, and is well sheltered from the north and east by the wood. As the Daisies now flood the meadow with white, so very shortly will the Buttercups carpet it with yellow. Later the purple of the Self Heal will predominate, to be superseded in its turn by the yellow Hawk-bits. This meadow is a favourite resort with me, and I should like you two boys to fall in love with it. If you wish to be naturalists, you can have plenty of practice here. Why not visit it at least once in each week of the year, and make notes in your diaries of the things you observe each time you come ?

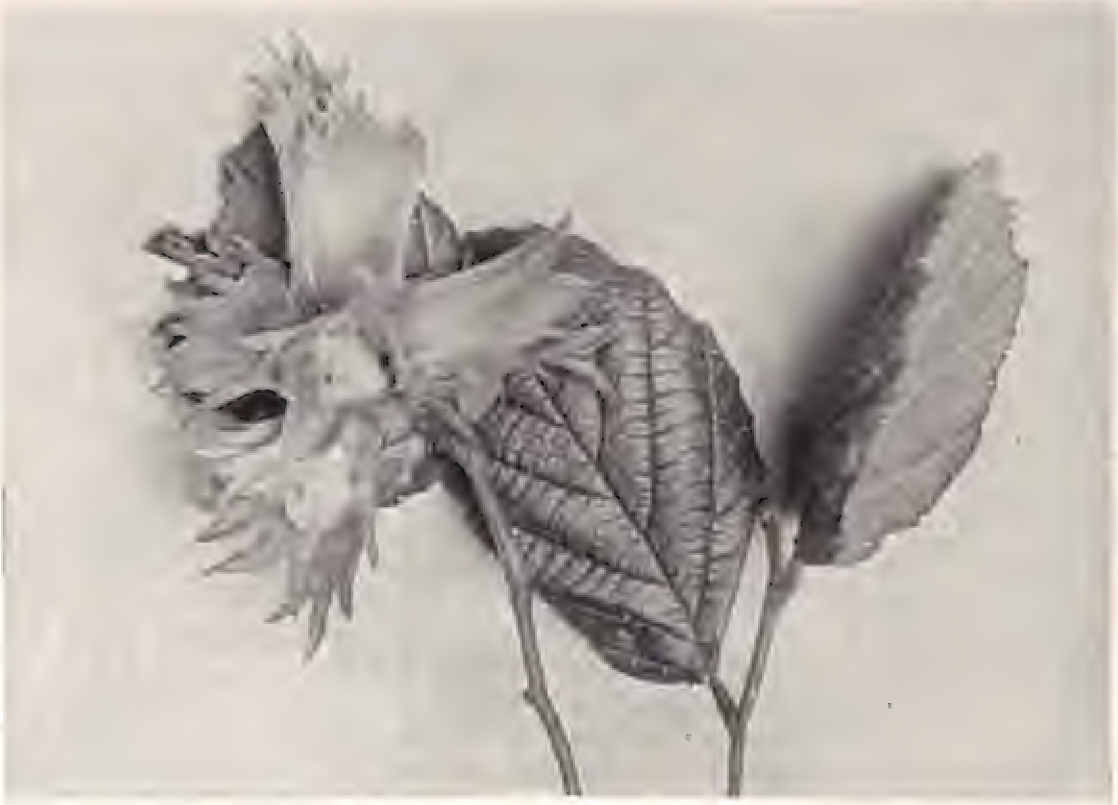
Ah, another butterfly! This time a rather ragged Small Tortoiseshell (*Vanessa urticæ*). Let it settle, so that you can get a good look at it. The base colour of the wings is a rich orange-red. There are a number of black markings on the fore-wings, and two very dark patches extending from the bases of the hind-wings. Observe also the bands of colour which form the margins of the wings. The creature is sunning itself, and slowly raising and lowering its wings. You can see the under sides of the wings are quite different in appearance. The orange-red of the upper sides is replaced beneath by a stone-colour with dark markings ; and when the wings are folded the butterfly is not nearly so conspicuous as when they are extended. The Small Tortoiseshell is one of the commonest of our butterflies. Its caterpillar feeds on the Nettle. It is one of the creatures that can eat the leaves of the Nettle without being inconvenienced by its stings. The poet Burns says, "The best-laid schemes of mice and men gang aft a-gley" (*i.e.*, often go wrong), and the Nettle in scheming to protect itself against browsing animals, has failed to keep off the larvæ of the Small Tortoiseshell. The specimen we have just examined must have hibernated, for a new brood is not due until late in June, and thus the ragged dress we noticed is accounted for. Somebody said to me the other day that butterflies lived only for twenty-four hours. That, of course, was a wrong statement to make. We have seen two butterflies to-day that have endured a rigorous winter.

The Small Tortoiseshell took our attention from the Buttercups. The Creeping Crowfoot has a lowly growth, but it is a very prolific and troublesome weed. It sends out runners which root and form new plants at their joints. The Scottish farmers call it "Creeping Crawtaes" and pronounce maledictions upon its sinful heads. The Bulbous Crowfoot has a bulbous root, and an upright growth to the extent of about a foot. The Upright Meadow Crowfoot has an erect stem, which sometimes reaches upwards of three feet in height. Don't confuse the last two Buttercups as some folk are apt to do. There is one point which will settle any difficulty you have in distinguishing them. The Meadow Crowfoot has round, hairy leaf-stalks, whereas those of the Bulbous Crowfoot are hairy and *furrowed.*

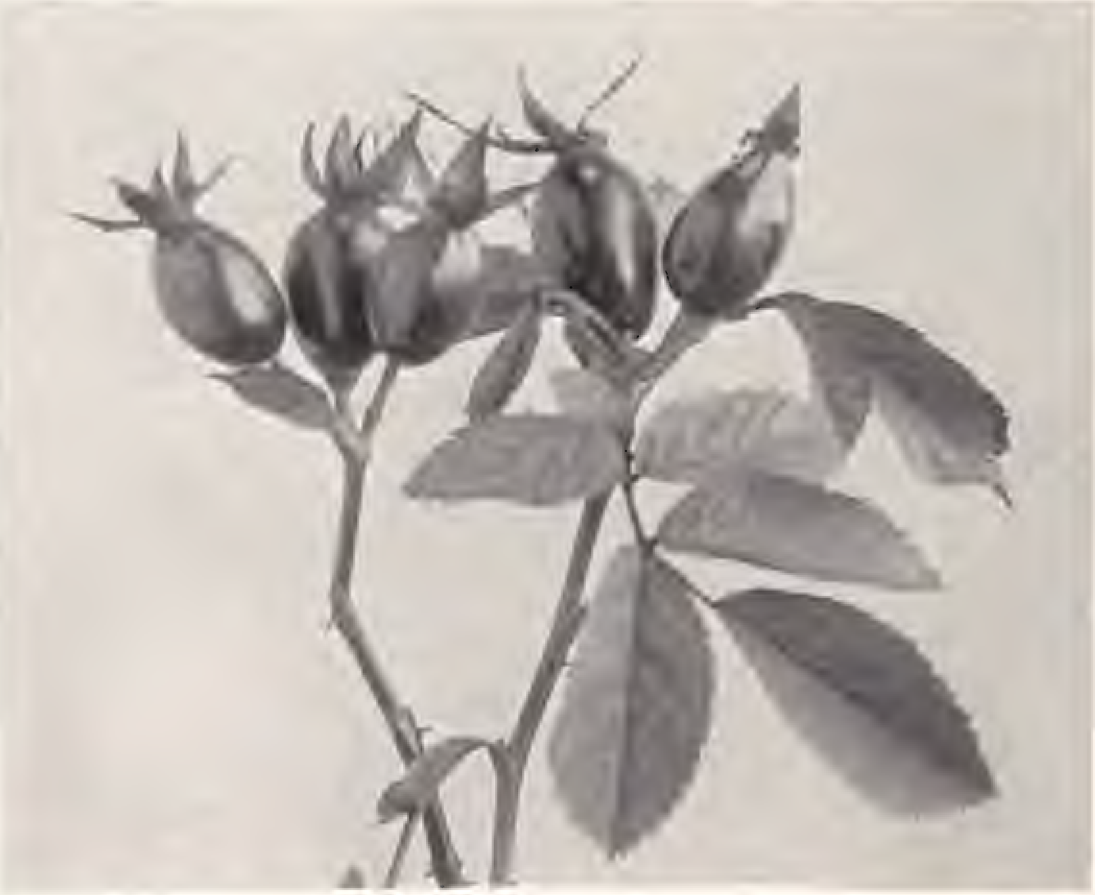
I see a few specimens of the Mouse-ear Hawkweed (see p. 138), and a patch of Red Clover (*Trifolium pratense*), about which some bees are humming. They are after the honey, with which Clover abounds. Clover belongs to the Pea and Bean tribe, the Natural Order Leguminosæ. Look at this head I have just picked. It is composed of a crowd of little flowers; those from a little below the middle to the top are pointing upwards and looking fresh, while those round the base of the head are hanging downwards and becoming discoloured. The fact is, those that are hanging have been fertilized by the bees, whilst those that are holding themselves up are waiting to be fertilized. As soon as they have secured all the service they require from the insects, they too will drop their heads. The bees seem to know this habit of the clover, and they make for the fresh flowers, not needing to spend any time upon fruitless visits. I call that a clever arrangement, do not you ?

Rabbits ! They don't like the look of us, and are scuttling to their holes as fast as their legs will carry them. I'm sorry they won't stay to be photographed. I have heard it said that the white underneath a rabbit's tail—that white which the animal displays as it runs—is a danger signal. When the white flag appears, the whole batch runs after it, displaying white flags for stray relations to see. It does seem from the way in which rabbit-scuttle to their holes, as it were by common arrangement, that there is truth in the idea. How can you tell the difference between a Rabbit and a Hare ? Well, the Rabbit lives in a burrow and has its young ones there ; the Hare does not make a burrow, but rests in what is called a "form," which is simply a bed in a tuft of grass, and it makes a nest for its young in a hollow on the surface of a field. Hares are not so gregarious as Rabbits, and their hind-legs are much longer in relation to their fore-legs. If you have once seen a Hare running, and remember how a Rabbit runs, you could never mistake the one for the other.

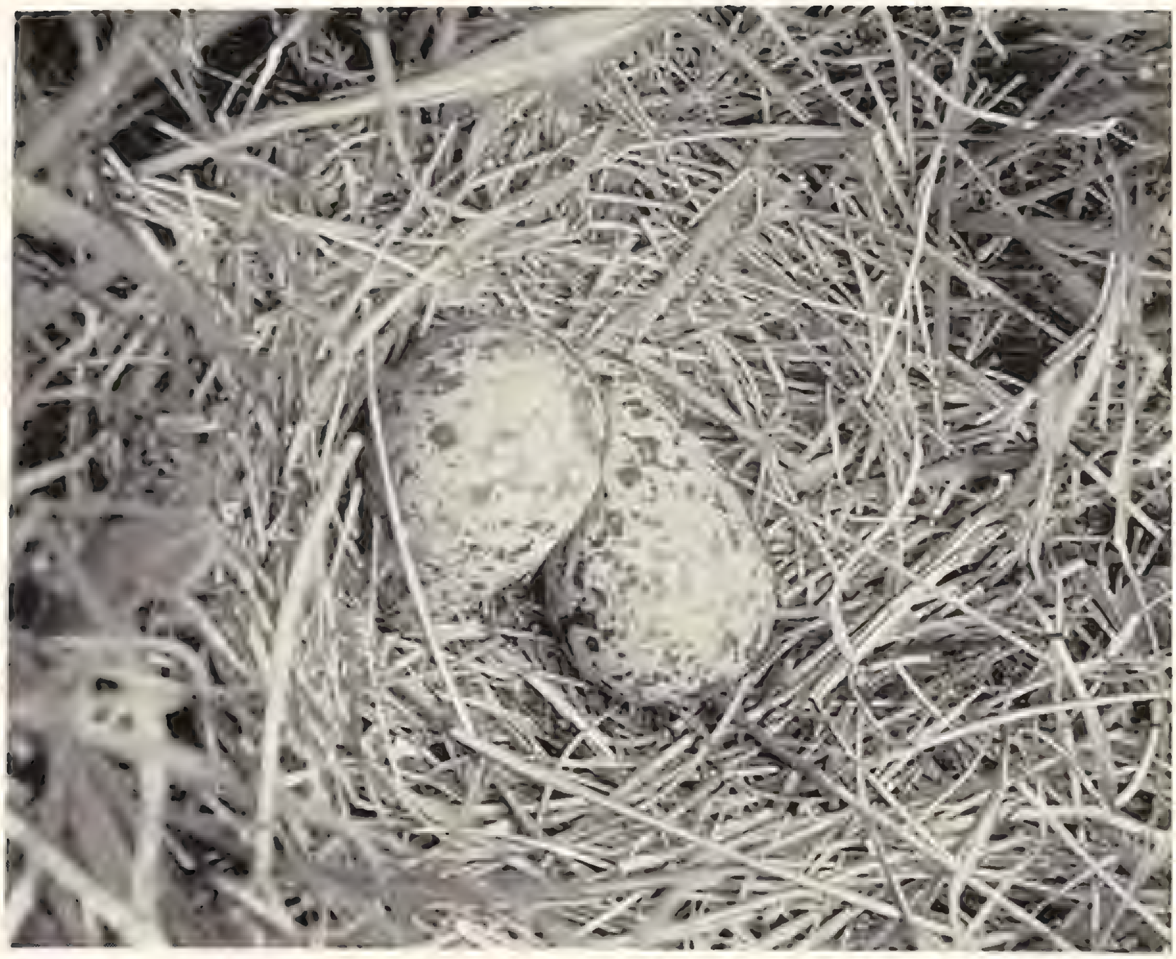
At last we are at the quarry, a delightful place where one can find shelter from any wind that blows ; and it is a splendid hunting-ground for the naturalist. This part is no longer worked, and stone is taken



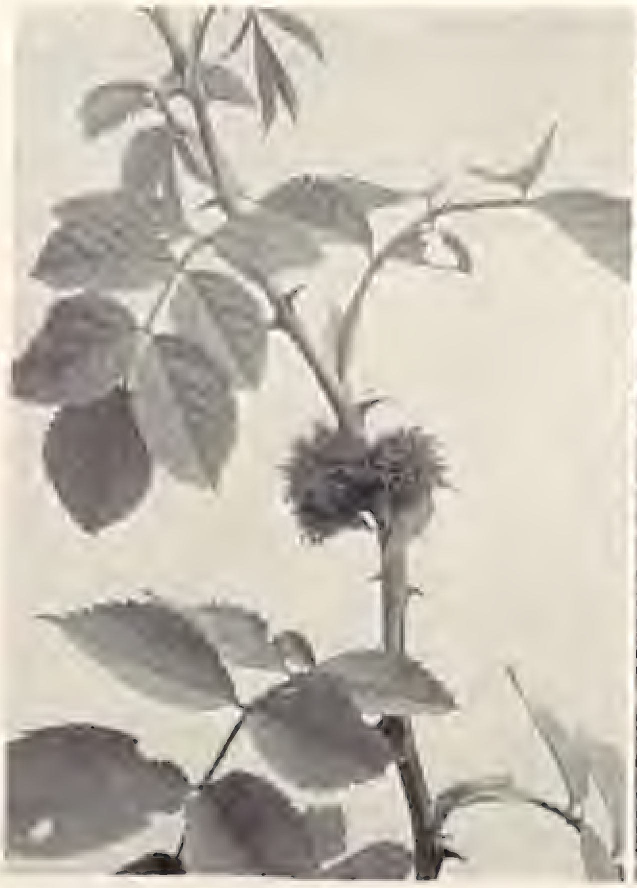
(*a*) Hazel-Nuts. *P.* 194.



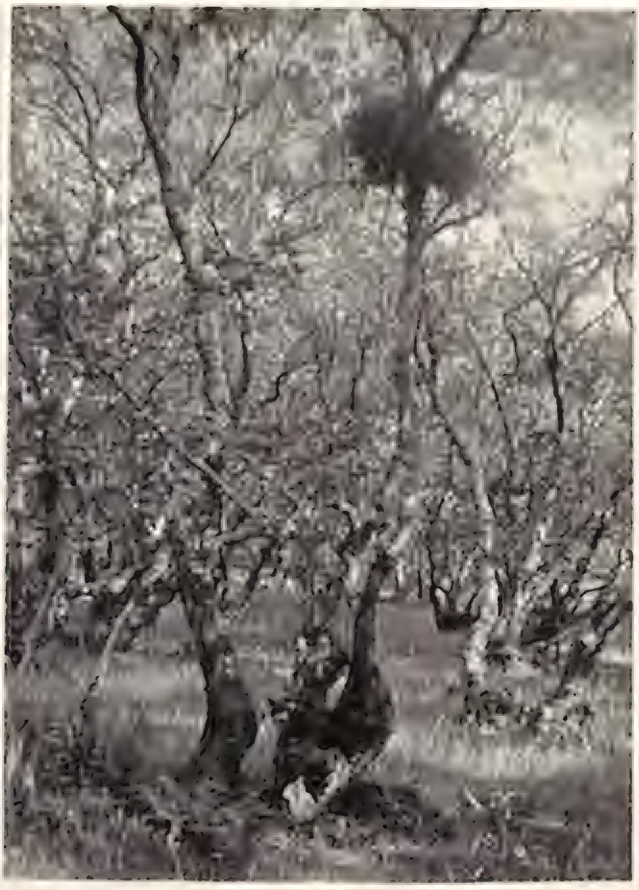
(*b*) Fruit of Dog-Rose. *P.* 180.



(*a*) Lapwing's Nest and Eggs. *P.* 205.



(*b*) Rose Bedeguar. *P.* 179.



(*c*) Witches' Broom. *P.* 179.

only occasionally from that part which shows evidence of recent working. Indeed, I am told that the good stone is nearly worked out, and it will not be long before the place is deserted entirely by the quarrymen. The sandstone, of Carboniferous age, is an "outcrop" (see p. 36); it forms the ridge which can be followed right across the meadow. It dips at an angle of about 30 degrees. In going across the ridge, you walk over the upturned edge of the bed, and by measuring the distance across the ridge, you can roughly calculate the thickness of the bed, of which the ridge is an outcrop. I make the distance to be upwards of 150 feet, so the bed will be about that thickness.

The hill, which begins to rise steeply about fifty yards away, is of volcanic origin. It is composed of lavas which flowed from a volcano that was active in the earliest Carboniferous times. If everything were now as it was when the sand forming this sandstone was deposited, the ground on which we are standing would be higher than the hill yonder. But this ground has sunk, and in sinking, the edge of the sandstone has turned up against the lavas: hence the outcrop. It is like the upturned edge of the paste in a pie-dish. The bulk of the sandstone bed is away down below the surface. It is only the edge we see. And as the paste in the bed of the pie-dish is covered with fruit, so is the sandstone covered with other material, except just at its upturned edge. There is a line of "fault" between the lavas and the sandstone. The latter has been faulted down very gradually, slowly but surely. I can show you a place on the side of the hill where the rock is quite polished by the gradual sliding down of the sandstone. It is called a *slickenside*.

When I was last here I saw the impression of a *Lepidodendron* (see p. 98) on a sandstone surface. See, it is here yet, quite undisturbed, as I was afraid it might have been, and beautifully distinct. The scalelike markings can be seen clearly. You may be able to find some pieces of *Calamites* (p. 98), *Sigillaria* (p. 101), and *Stigmaria* (p. 101) amongst that heap of stones which have been recently quarried. It would be nice to get some good specimens for the museum at home, our collection of Carboniferous plant remains not being, at present, as good as it might be.

What, half-past twelve o'clock! The time has passed far too rapidly. I expect you are as hungry as I am, so we will make this the end of the present chapter of our ramble. We can discuss a few matters while we take our lunch, and begin another chapter when we have rested and refreshed the inner man.

CHAPTER VIII

A RAMBLE IN MAY: LUNCH-TIME

We will take our lunch on that dry bank, from which we can get a view of the woods and the streamlet that skirts the meadow. This is a good position to take up, and I have no doubt we shall see plenty of things to talk about while we enjoy our sandwiches.

The water from a spring empties itself into the brook just below us, and I believe I see some Watercress (*Nasturtium officinale*) growing at the edge of the stream ; a few sprigs of it would make a lovely and a healthy salad. I think you might gather some, Victor ; wash it carefully in the spring-water, and bring it here as quickly as you can.

You call that Watercress ? What a mistake ! That stuff is Brooklime (*Veronica beccabunga*), a member of the Speedwell family which haunts brooks and ditches. It has opposite, elliptical leaves quite different from those of the Watercress, which are pinnate and alternate. Watercress belongs to the Cruciferæ, and bears white flowers, whereas the Brooklime is one of the Scrophulariaceæ. Neither plant flowers until June, when you will be able to see that Watercress bears white flowers, and the

Brooklime lovely little blue flowers in axillary racemes.

Profit by your mistakes. After this little lesson I don't think you will make a similar error again. Go back to the brook, and bring us Watercress this time, please.

The other day a naturalist friend told me a remarkable story about an incident in bird-life which happened in the quarry we have just visited. He was rambling quietly in the quarry, when he saw three Pied Wagtails (*Motacilla lugubris*)—two males and a female. It was the mating season, and both males were anxious to mate with the lady, who, however, seemed "coy and hard to please." She seemed to think, "How happy could I be with either were the other dear charmer away!" The males got angry, and began to fight, the lady looking on. One of the males settled on a stone and displayed his charms, dipping his graceful tail and swaying his lovely body in proper Wagtail fashion. He was not allowed to enjoy his advantage long, for the other male swooped down on him, and literally knocked him off his perch. The love-lorn swain picked himself up, and flew to a jutting crag on the quarry face, followed by his angry antagonist, who dashed at him, and fastened his beak into his neck. Both fell to the ground, turning repeated somersaults in their descent. Alas! the first male could display his charms no longer; he was picked up panting by my friend, and died from a broken neck in a second or so. The victorious male made up to the lady, and the two flitted about in lover-like manner, just as if no tragedy had happened. In the animal world it is a common thing for the females to select mates who have displayed superior strength, and many a love-affair is settled through "trial by combat."

You think there is a terrible amount of bloodshed in Nature ? As the poet said, "Nature is red in tooth and claw." Even plants fight. But there is a good amount of co-operation in Nature too. A few miles from here there is a colony of Black-headed Gulls (*Larus ridibundus*). Thousands of them make their nests and rear their families on a little island in the middle of a good-sized lake. They are massed together in a perfect crowd, and when an enemy approaches he is completely outnumbered, and easily driven off by a large company of the Gulls. They say that "Birds of a feather flock together," and this is extensively true ; the flock may quarrel among themselves, but they are as one man when attacked by a common enemy. At any rate, human beings, with their intelligence, should not take example from the savagery of the lower animals ; on the other hand, they should learn the good lesson of co-operation which Nature teaches, and live together in brotherliness and good-will.

Listen to the Skylarks (*Alauda arvensis*) ! I hear several singing within a short distance of one another. Like us, they are enjoying the good weather and taking advantage of the sunshine. It is remarkable how sunshine and blue skies draw the songs out of our hearts ; and, on the other hand, how storms appeal to our strength, and give us a stern determination to overcome difficulties. The folk of the "Sunny South" are a tuneful people ; but the men of the Highlands, who see Nature in her frowning moods and contend with torrents and tempests, are a hardy and determined folk; they may sing less, but they accomplish more.

But the Skylarks. I suppose you will have learned Shelley's famous ode to this soaring, songful bird. It commences:

"Hail to thee, blithe spirit—
Bird thou never wert—
That from heaven or near it
Pourest thy full heart
In profuse strains of unpremeditated art.

Higher still and higher
From the earth thou springest:
Like a cloud of fire,
The blue deep thou wingest,
And singing still dost soar, and soaring ever singest."

Several poets have attempted to immortalize the Skylark in their verses, but I think Shelley has succeeded beyond them all. I like the concluding lines of the ode:

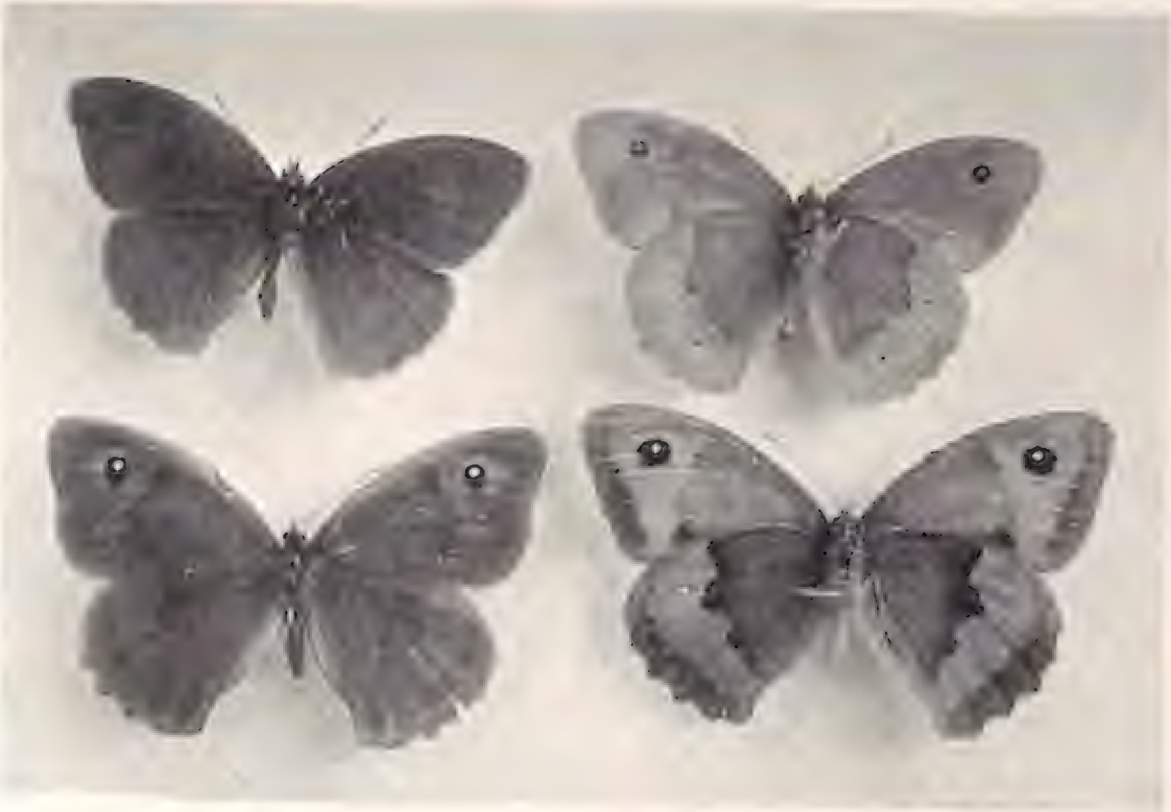
"Teach me half the gladness
That thy brain must know;
Such harmonious madness
From my lips would flow,
The world should listen then as I am listening now."

It always seems significant to me that this bird, which sings so gloriously and soars so high, makes its simple nest and rears its family on the ground. There seems to be a suggestion of poetry in the facts. Does it not often happen that the sweetest music, the most moving poetry, and the noblest lives emanate from the humblest and most lowly hearts?

While we are thinking about birds, just take the field-glass and watch the common Sandpiper (*Tringoïdes hypoleucus*) that is slowly and jerkily making its way along the brook, heading up the stream· Notice that it has a habit of dipping its tail after the manner of the Wagtails, but not nearly so gracefully. It seems to be always trying to balance itself. You will see it is bigger and, to my mind, more awkward than the Wagtails, and it is not nearly so gaily clad. I am told that the Sandpiper spends its winters in Africa, and visits us about the end of April. Just think of the miles that bird has flown, and what a traveller it is! Common Sandpipers do not nest in this district, but their nests are commonly found farther north and in Scotland. Don't you remember the great numbers of this bird that we saw on the west coast of Scotland in June, 1910? I wished to photograph one of their nests, but had great difficulty in finding one, although I knew there were plenty about. These birds are very cunning about their nests. If disturbed while sitting, they fly away very silently and with a peculiar kind of flight. When they get some distance away they utter weird sort of cries, which are intended to mislead a hunter for their eggs or young. They seem to say, "Here's the nest! Here's the nest!" and an unskilled searcher is often led to look for an hour where the nest is not. You may depend upon it that the nest is always some distance from the "weet-weeting" Sandpipers; they are deceivers ever. Someone said, "All men are liars." Such a statement would be highly true of these birds. I did not, with all my searching, have the honour of finding a Sandpiper's nest, but two were pointed out to me by a girl who had blundered across them; so I got my photograph, and a good one, too. The nests are poor affairs ; usually a little dried grass in a hollow in a bank near water.

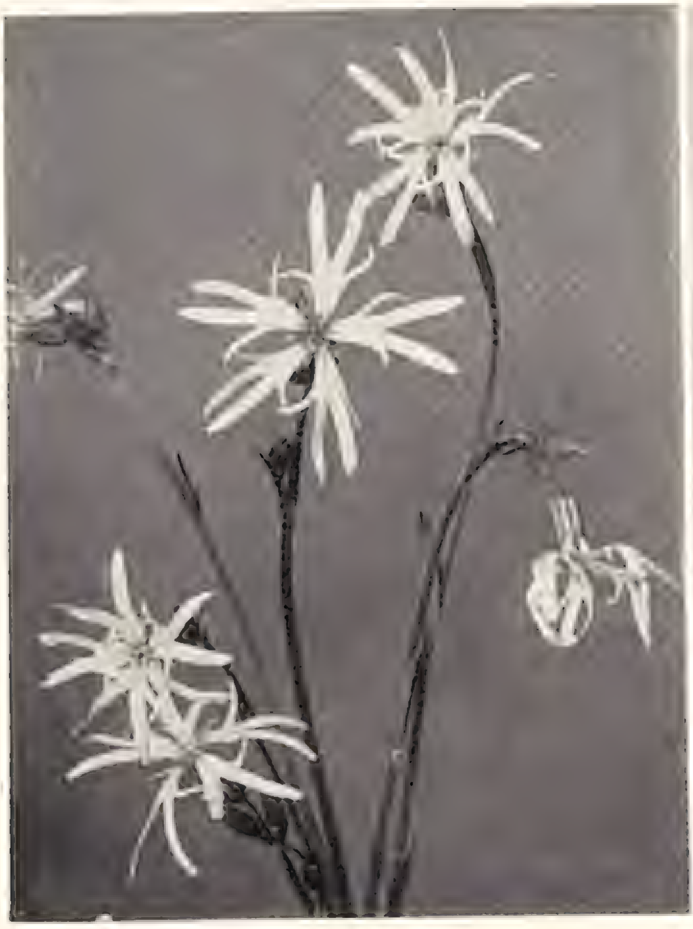
I suppose you know the Yellow Iris (*Iris pseudacorus*), the flowers of which are sometimes called "Flags." I see a clump growing down there on the moist ground by the brook. The leaves of this plant are like swords. There are plenty of buds, but no flowers yet ; some buds are beginning to burst, and a few flowers will be open in less than a week if the weather continues favourable. The Iris is a true Monocotyledon ; it could not be mistaken for anything else. Its beautiful showy yellow flowers glorify damp and muddy places, which, without them, would be thought uninteresting, and far from wholesome. The styles of the pistil of the Iris are very like petals, so much so that the unskilled observer might declare they were petals. I have known two or three persons who used to collect Iris seeds and roast them ; they said they made a good substitute for coffee.

The Water Avens (*Geum rivale*) grows abundantly at the side of the brook. This is a member of the Rose tribe, Natural Order Rosaceæ. The flowers, which have a drooping habit, have a dull appearance, the calyx being tinged with a dull purple, while the petals are a blend of purple, pink, and orange. The name of the plant is a clear indication of its love of damp places, particularly by the sides of streams. Our friend "Johns" gives the months of June and July as the flowering time of the Water Avens, but I have seen it in splendid bloom as early as April 30, and it has flowered by this brook during the whole of the present month (May).

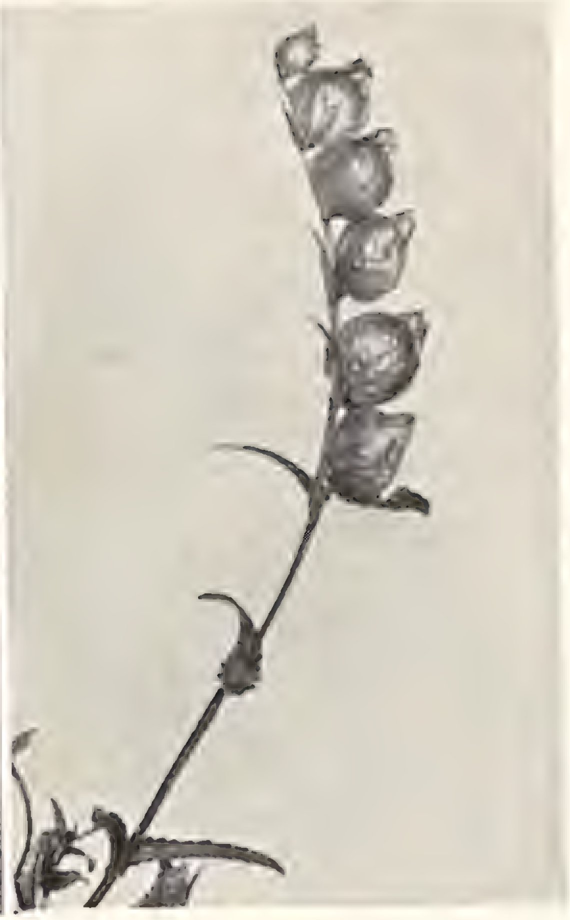


(*a*) Meadow Brown Butterflies (male and female, upper and under sides). *P.* 205.

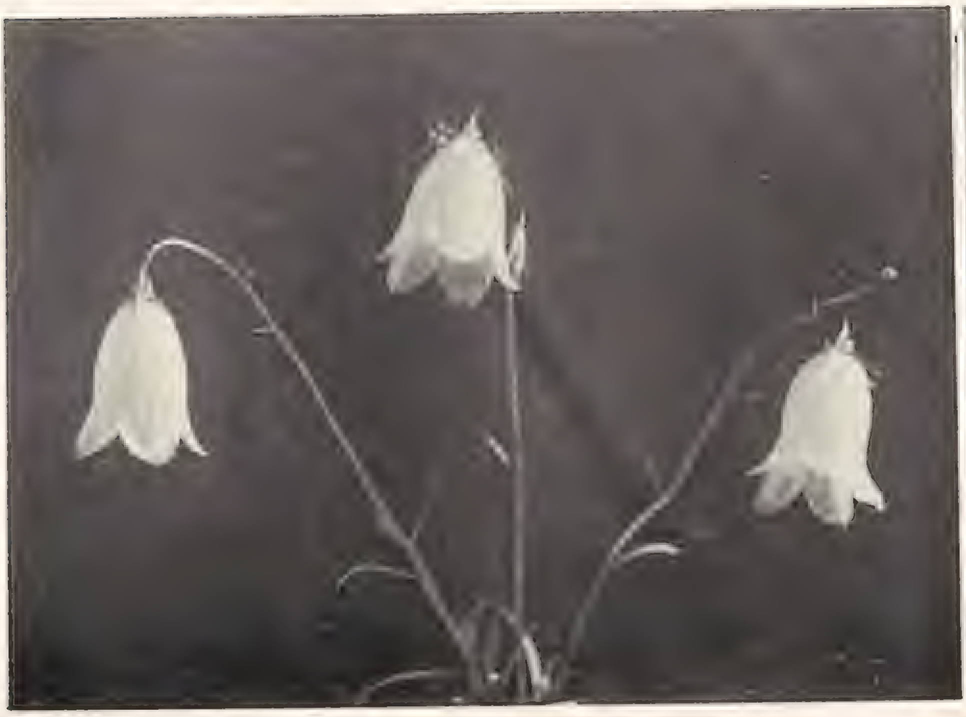
(*b*) Gorse. *P.* 206.



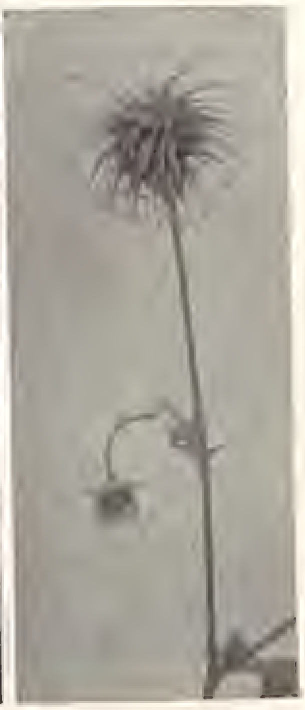
(*a*) Ragged Robin. *P.* 142.



(*b*) Yellow Rattle. *P.* 204.



(*c*) Harebells. *P.* 192.



(*d*) Fruit of Herb-Bennet. *P.* 177.

There is another species of Avens, called the Herb Bennet (*Geum urbanum*), which frequents thickets and hedges. It is more erect than *G. rivale*, and its small yellow flowers do not droop. I have never seen this in flower about here until the middle of June. By the end of July you will be able to see lots of this plant in seed, and if you push by them they will hook themselves on to your clothes. Each carpel is crowned with a hardened style, terminating with a hook. The hook clings to the fur of rabbits and other animals, as well as the clothes of man, and thus the seed is carried long distances from the parent plants. In this remarkable way the seeds of the Wood Avens, or Herb Bennet, are dispersed and new ground is insured for future plants.

I have often remarked that it is wise for a naturalist on the prowl to sit down on some mossy bank or other inviting ground for an hour or so. I heard of some friends who were out hunting for what they might see the other day. They climbed a steep hill, and thought it would be good to sit down and rest after their exertions; as a consequence, they spied what they might never have seen had they continued to walk—the Moonwort Fern (*Botrychium lunaria*), which, indeed, is a most interesting plant. Most ferns bear spores on the backs of the fronds, but this one has a split frond, one half of which bears semicircular or moon-shaped frondlets, while the other bears only spore cases, which are held upright and appear like clusters of small berries. As we sit quietly we may see many interesting things—beetles, grasshoppers, spiders, ants, bees, wasps, flies, and innumerable other creatures, as well as plants. If we are very still, birds will approach us, and even rabbits will gambol not far away. That is one thing the young naturalist has to learn—to be quiet and patient. Use your eyes as much as you can ; open your ears to every sound, but make no movement and no noise. I was once sitting quietly on a hedge-bank, seeing many things to interest me, when a Hare came leisurely along a track, and actually jumped over my outstretched legs. I had never had so good a look at a Hare in a state of nature before. On another occasion I was resting on a boulder in the bed of a Scottish burn, when I noticed a big Rat gliding noiselessly about here and there without being at all distressed by my presence ; perhaps he thought I was part of the scenery. I have even had butterflies settle on my coat and sun themselves there. Study to be quiet.

Had we not been sitting here, we might have overlooked the Moss which grows all about us. It is bigger and coarser than those Mosses which grow on the rockeries and walls at home. Here is some over six inches in height, green in the upper parts but looking withered at the base. What is particularly interesting is the stalked capsule which each plant seems to bear. See, each capsule is covered by a little brownish hood, which I can remove, just as if it were a candle-extinguisher ! Now the hood is removed, you see the naked capsule, which is closed at the top by a kind of beaked lid. There is a little ring which marks the junction of the lid and the main body of the capsule. Very soon that ring will break, the lid will fall off, and the spores which are ripening in the capsule will escape. From the spores new Moss-plants will develop. I don't think the plant has an English name ; its scientific name is *Polytrichum commune.* Mosses are such lowly plants that they seem to have been ignored by all but a few botanists. Yet they have a most interesting life-story, which I had better not trouble you with now ; but I am sure, if you keep up your Nature interest, you will some day want to know something about it. There are about six hundred kinds of Mosses in Great Britain, some of them exceedingly small. One cannot study them without the aid of a microscope, but I can tell you from experience that, once you get on to their study, you are not likely to give it up in a hurry. I could not imagine a more fascinating group of plants.

What is that red mossy growth on the Wild Rose (*Rosa canina*) ? Oh, that is called a Rose Bedeguar. Is it not curious ? and how lovely is the rich red colour ! "Robin's Pincushion" is another name which has been given to the growth. It is caused by the larvæ of the Gall Gnat (*Rhodites rosæ*) ; if you open the growth, you will find some inside. The eggs or larvæ cause a kind of irritation to the plant, and the growth is the consequence. This reminds me of the bird's-nest-like growth which is commonly seen on Birch-trees. Many a time when I was a boy did I mistake these growths for bird's-nests. They are popularly called "Witches' Brooms" ; some of them are caused by a fungus, which, of course, is a lowly plant, and others by a Gall Mite (*Phytoptus rudis*). So, you see, these growths are the homes of curious creatures or other plants. Oak-apples are not the fruit of the Oak, but growths due to another gall-fly. There are numerous kinds of galls, each one having its own particular cause, and being a peculiarity of the plant on which it grows. There is no end to Nature: galls alone provide study for a lifetime.

In coming along the lane this morning I noticed the strong growth of the Brambles. They should be in bloom fairly soon. The Bramble gets on well in a hedge, because it can hook itself on to the Hawthorn by its prickles, and pull itself up to the light. It seems to have equipped itself for such a situation; it does not thrive so well where it is left to itself, and has no other plant to climb by. By the time the Bramble is in full bloom the summer is well advanced, and, as you know, its luscious fruit is not usually ripe until September, when we all go blackberrying, and enjoy the good jam and jelly. One might say the Bramble is exceedingly cunning. It wraps its hard seeds in delicious pulp, which the birds eat; but the seeds themselves are indigestible; they pass through the body, or are scattered by the birds as they eat the fruit. In this way the parent plant attempts to avoid overcrowding. It does not want its youngsters to take away its supplies, so by a strange device it sends them abroad. The same trick is adopted by the Rose and Hawthorn: the red "hips and haws" attract the birds, who feed on the fleshy parts, and scatter the seeds so neatly packed inside.

Are there any snakes about here? I have occasionally seen Adders (*Vipera berus*) among the Heather on the hill yonder; that specimen I have in the museum at home was caught there; it was a big one, no less than two feet long, which is about as big as Adders grow. It was easily caught. The friend who gave it me saw it sunning itself after a good meal; it seemed too well filled and lazy to care about moving. My friend approached it with ease, held it down to the ground by pressing the point of his walking-stick on its neck, and then prevented it from doing any damage by removing its poison fang with a knife. The bite of an Adder is not fatal, but it might cause a serious illness. No one need have any difficulty in knowing an Adder when he sees one; none but an ignoramus would mistake it for the common Ring Snake. The Adder is more serpent-like than the Ring Snake, thick in the middle of the body, and tapering quickly to both neck and tail. The Ring Snake is a more slender reptile. The Adder is a dull yellow, with black spots linked into each other along its back, while its sides have triangular black markings. It is black underneath. The Ring Snake is greenish-yellow in colour; it grows to a greater length than the Adder, and its tail is drawn out to a fine point.

I saw a paragraph in the newspaper the other day about our famous politician, Mr. Lloyd George, having an encounter with an Adder. As the story was told, it would seem as if there had been an alarming fight, and that our Chancellor of the Exchequer was in danger of his life. I'm afraid the newspaper reporter must have drawn upon his journalistic imagination; he certainly could not have been a naturalist. Adders do not attack men unless they are cornered; and even if they did make an attack, it would be the easiest thing in the world to get out of their way. I have seen scores of Adders in the Scottish Highlands, but I have never come across one that was not eager to get out of my way.

Ring Snakes deposit eggs from which their young are hatched, whereas Adders bring forth their young alive. The former are termed *oviparous* (Latin, *ovum* = egg ; *parere* = to bring forth), and the latter *viviparous* (Latin, *vivus* = alive ; and *parere*). I have read many stories about Adders swallowing their young when threatened by danger ; but the stories are discounted by many observers, and as I have never seen such a thing happen I don't feel in a position to give an opinion on the subject. Mr. A. Nicol Simpson F.Z.S., a good Scottish naturalist and competent observer, says such stories are the outcome of superstition.

Adders will swim when it is necessary for them to do so, but they do not seem to care for the water ; Ring Snakes seem to delight in it. I have seen specimens over a yard long swimming with their heads above water along the big drains of the Fen district. I must tell you that when I was a small boy I was an enthusiastic naturalist, and spent all my holidays in prowling about the country-side. One day I had the fortune to capture a Ring Snake fully four feet long. At first I tried to kill it by hitting it on the head, but that method did not work ; then I called to mind the old wives' story about killing snakes by blows on the tail ; I tried that way, but without success. By this time I remembered hearing that snakes never died until sunset ; even if you cut them up into small pieces, each piece would wriggle until sundown. So I determined to hold my specimen by the neck, coiling its body round my arm, and to carry it home that way. I intended to produce it at supper-time, when I hoped to put my sisters into a state of consternation. However, I had not walked very far when the beastly reptile exuded a stench on to my coat sleeve that made me drop him in an instant. Such an indescribable stench it was ; I had to wash my sleeve as well as I could in a stream, but I was not able to get entirely rid of the smell until I could get the use of soap and soda. Ring Snakes have some glands in their bodies from which they can exude a stinking fluid when roughly handled. Perhaps that power is a protection to their kind. I cannot imagine any animal or man desiring to retain hold of a Ring Snake in spite of the smell.

As I have said, I have seen Adders on the hill, but I have not found any Ring Snakes in this district. What are known as "Slow" or "Blind Worms" are common. They, however, are not snakes ; indeed, to be correct, they are legless lizards, which do not as a rule grow more than twelve inches long. Why this reptile should have been called "slow" or "blind" I cannot understand. It can move quickly enough when it wants to get out of danger ; it will sometimes even leave its tail in your hand if you happen to have caught it by that appendage ! Surely a convenient way of escape, but an example we could not easily follow ! We are reminded of the Brittle-stars (p. 60), which will leave parts of themselves in their enemies hands, arms, or mouths, and make good their escape. And the reptile is not blind, although its bright eyes are very small. When very young, the Slow Worm has a whitish appearance, but as it grows it becomes copper-coloured. It haunts manure-heaps, where it often brings forth its young, always in a living condition (viviparous), and it may also be found in thickets and heaps of rubbish.

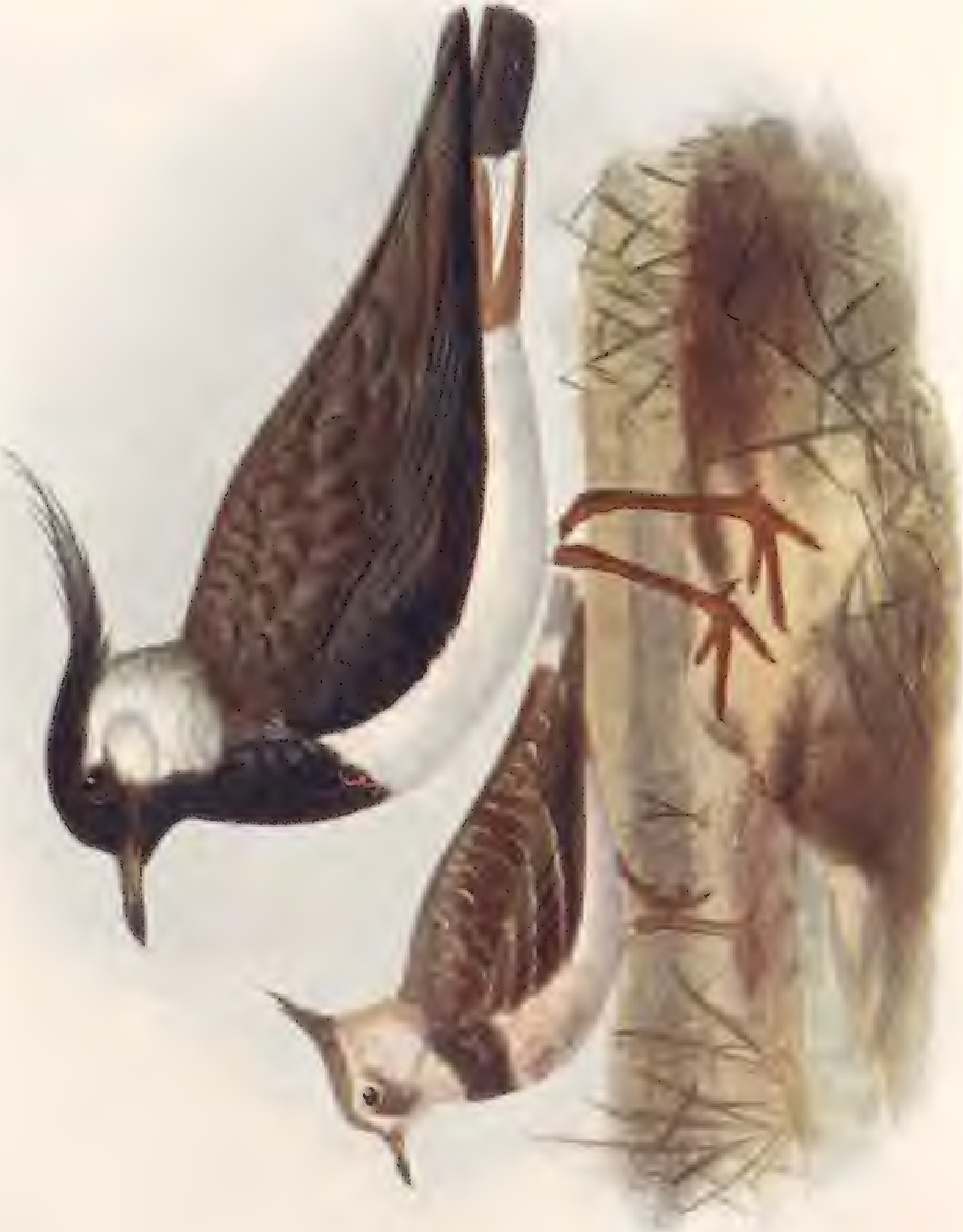
Before we leave this delightful resting-place, I want to tell you something about the meanings of some Latin words that are often used as specific names of plants. When you know those words and their meanings you will the more easily understand the habits of the plants to which they are attached, or the uses to which they have been put.

The Watercress, as I told you, is named *Nasturtium officinale.* The word *officinale* comes from the Latin *officina* = a workshop, or laboratory. The term is applied to plants that are, or have been, used medicinally. Watercress is supposed to have valuable medical properties ; hence its specific name *officinale.* The same term is applied to the Great Wild Valerian (*Valeriana officinalis*), of which I see some specimens about ready to flower by the side of the brook ; and to a number of other plants. *Vulgaris* is another commonly used word ; it means " common," and is applied frequently to common species of genera ; take, for example, the Yellow Rocket (*Barbarea vulgaris*), which grows in the quarry, as well as by the side of the stream. The word *perennis* is from *per* = through ; *annus* = a year ; and it indicates that the plant to which it is attached is a perennial, living for several years. The Daisy is named *Bellis perennis. Paluster* is from *palus* = a swamp or marsh ; the word occurs in *Caltha palustris,* the Marsh Marigold.

(*a*) Sea Campion. *P.* 232.

(*b*) Creeping Crowfoot. *P.* 165.

PLATE 49



Lapwing or Pee-wit. *See page 205.*

Where you find the word *palustris* or *palustre* in the name of a plant, you may be sure that it grows specially well in marshes. *Pratensis* is from *pratum* = a meadow ; the word is used in the names of plants that are generally found in meadows, such as the Meadow Crane's-bill (*Geranium pratense*), which you will see in flower hereabouts in the course of two or three weeks. It belongs to the Geranium family, and is a very handsome plant, its big blue flowers being singularly beautiful. *Sylvaticus* and *sylvestris* (*silva* = a wood) are words indicating that the plants to which they are applied are occupants of the woodlands. *Hirsutum* means rough or bristly ; *arvensis*, from *arvum* = a ploughed field, describes plants that grow in fields that have been cultivated ; *procumbens*, from *procumbo* = I fall forward, describes trailing plants. *Repens* and *reptans* mean "creeping"; *maritimus* (*mare* = the sea) means growing by the sea, and the same meaning is attached to *litoralis* (*litus* = the seashore).

You will find an occasional hour spent in looking up the Latin names of plants in the pages of your Latin dictionary will provide you with a lot of useful information, and I am sure you will have great enjoyment in the process. Next to being useful to your fellows, the greatest delight is discovered in the acquisition of knowledge ; and the more knowledge you possess, the more useful you can be.

We have had a long rest and a long talk ; now we will have a rinse in the brook and a good walk.

CHAPTER IX

A RAMBLE IN MAY : THE WALK HOME

OUR way is through the wood, up the hill beyond it, by the river for a couple of miles, then home. The ground is quite mossy and wet by the side of the wood, but we must have a good look at that bank of Primroses (*Primula vulgaris*). Just the vulgar Primrose, but how dull the spring would be without its glory! When my work has lain in big cities, surrounded by tracts of land rendered almost barren by chemical fumes and factory smoke, I have walked many miles to see a bank of Primroses. I hope my lot will never again be cast where these lovely flowers are so far from my home. The Primrose season will soon be over; I see signs of its passing in many decayed flowers. In another week or two the yellow stars will no longer adorn the mossy bank. But the flowers have done their work, and we shall see the good of it next spring. The leaves of this plant increase in size and numbers when the flowers are past; they lay in stores for the winter, and energy for the coming flowering season. The Primrose is an unscrupulous fighter; its leaves spring up like furled banners, but when they are well above ground they unfurl themselves, and lay themselves down, nearly flat. They want to smother the grass and other plants which seek the ground they occupy. Later in the year the grass may get above them, but by that time the leaves have laid in their stores, and, having done their work, are well satisfied to wither. The plants have plenty of life in their hidden roots; the grass will wither, or be eaten up in good time, and when the time comes for next season's Primroses they will be up betimes and get their business done before the grass can get above them. Messrs. the Primroses seem to say to the Grass: "We will hold you down and keep you from stealing our good things until we have served our own turn, and then you may do as you please. When we have got all we desire to have, we don't care what you do; even when you do your worst we can beat you; we shall be here again next spring as vigorous, smiling, and determined as ever."

There are Violets on the bank and all along the edge of the wood. These are not the Sweet Violets, but the Dog Violets (*Viola canina*); they have no sweet fragrance. Sweet Violets (*Viola odorata*) are rare in this district; I know of only one place where they may be found. Wild Pansies (*Viola tricolor*), which belong to the Violet order, are found in great abundance on the hill. We are sure to find some to-day, some of them quite yellow, others purple. That root of Pansies I have in the wild-flower garden at home was gathered from the hill; you know what fine flowers it is bearing; they are almost as big as some garden varieties. I expect they are thriving so well and growing so big on account of the good food they are getting, as well as the absence of necessity for struggling with other plants for the means of existence.

There is a little friend here that I hoped to see to-day—the Early Purple Orchis (*Orchis mascula*). He made his appearance in April, but it is not uncommon for a specimen to be a little later, and linger on even until June. People who see curious and beautiful Orchids growing in hothouses in which a tropical climate is artificially made and maintained all the year round are apt to forget that Great Britain possesses upwards of forty species and varieties of these plants. Our native Orchids are not so showy and conspicuous as those that are brought from the Tropics, but they are worthy of our most careful attention. To use an Americanism, Orchids are the " 'cutest " contrivances imaginable ; they display the greatest ingenuity in their methods of securing the services of insects in their fertilization. Look at this specimen of the Early Purple Orchis. The flower-stalk bears several flowers, each separate flower being attached to the stalk by a twisted ovary, and having a long hollow spur which contains nectar. One petal, which is three-lobed, forms a landing-stage for insects, and other two petals form a hood covering a pair of pollen sacs, which do not appear conspicuously like ordinary stamens. Just where the ovary is attached to the perianth, and beyond the pollen masses, there is a sticky surface, which forms the stigma. Now, I take my pencil and push it firmly into the mouth of the flower. See what has happened. The pencil has come into contact with a sticky foot, called the disc, at the base of the pollen masses, and now that it is withdrawn you see one of these masses, known as the *pollinium*, attached to the pencil. It has detached itself from the flower, and stuck itself firmly on to the pencil by means of its sticky base, and now you see it standing almost upright, with a slight backward slope. Watch what it does. It gradually bends over and forward, until the pollen mass is practically horizontal, pointing forward. Suppose a bee visits *Orchis mascula* to get honey out of its spur. It settles on the *labellum*, pushes its head into the mouth of the flower, extends its proboscis, and sucks up the delicious fluid. In the meantime, the pollen mass, or masses (for sometimes both masses become detached), have attached themselves by their sticky foot firmly to the head of the bee, probably right on one of its eyes. The bee leaves the flower with the pollinium on its head, and as it is proceeding to another flower for more honey the pollinium turns forward as on the pencil. When the bee puts its head into the next flower, it has to push the pollen mass against the stigma, and thus the flower gets fertilized. Orchids don't desire to fertilize themselves, and such a device as the one I have illustrated is resorted to in order to secure cross-

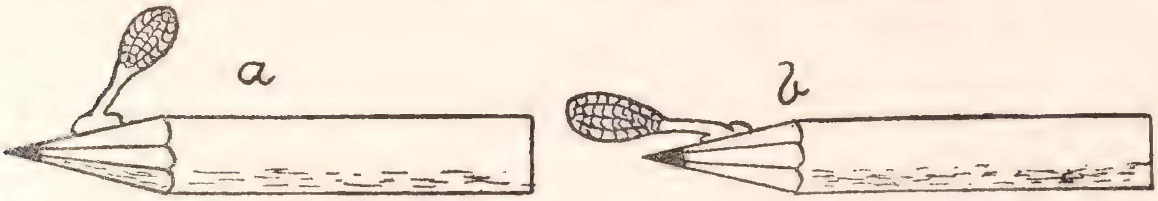


FIG. 55.—FERTILIZATION OF ORCHIS MASCULA (PENCIL EXPERIMENT).

a, First position of pollinium; *b*, second position of same.

fertilization. You would almost think that the Orchis had calculated its plan, and might readily give it credit for much intelligence.

The great naturalist Charles Darwin wrote a book called "The Fertilization of Orchids," which describes many wonders of the Orchid family. In it he refers to an Orchid which is found in Trinidad, named *Coryanthes speciosa.* He described the habits of this flower also in his "Origin of Species." He wrote: "This Orchid has part of its labellum, or lower lip, hollowed out into a great bucket, into which drops of almost pure water continually fall from two secreting horns which stand above it; and when the bucket is half full, the water overflows by a spout on one side. The basal part of the labellum stands over the bucket, and is itself hollowed out into a sort of chamber with two lateral entrances; within this chamber there are curious fleshy ridges. The most ingenious man, if he had not witnessed what takes place, could never have imagined what purpose all these parts serve. But Dr. Crüger saw crowds of large humble-bees visiting the gigantic flowers of this Orchid, not in order to suck nectar, but to gnaw off the ridges within the chamber above the bucket; in doing this, they frequently pushed each other into the bucket, and, their wings being thus wetted, they could not fly away, but were compelled to crawl out through the passage formed by the spout or overflow. Dr. Crüger saw a 'continual procession' of bees thus crawling out of their involuntary bath. The passage is narrow, and is roofed over by the column, so that a bee, in forcing its way out, first rubs its back against the viscid stigma, and then against the viscid glands of the pollen masses. The pollen masses are thus glued to the back of the bee which first happens to crawl out through the passage of a lately expanded flower, and are thus carried away. . . . When the bee, thus provided, flies to another flower or to the same flower a second time, and is pushed by its comrades into the bucket, and then crawls out by the passage, the pollen mass necessarily comes first into contact with the viscid stigma, and adheres to it, and the flower is fertilized." That, boys, is as remarkable a plot, devised by a flower, as any stratagems related of the elusive Scarlet Pimpernel by the Baroness Orczy.

It seems to be taken for granted that our *Orchis mascula* is visited only by bees ; but I know that some moths must visit it too, for I have seen moths with pollen masses attached to their eyes. At home I have a photograph of such a moth on which the pollinium can be distinctly seen.

The Spotted Orchis (*Orchis maculata*) is growing as freely as usual ; you see specimens holding up their heads yonder. The flower is not purple like that of *Orchis mascula*, but whitish, with purple markings, and the flowers are more crowded on their spikes. I also see an odd spike or two of the Marsh Orchis (*Orchis latifolia*), with its rich purple flowers, but this plant will be more abundant next month. You can try the pencil experiment with both these species, with a similar result. Two other Orchids are frequently found in this district—the Fragrant Gymnadenia (*Gymnadenia conopsea*), or Sweet-smelling Orchis ; and the lovely, elegant, and fragrant Butterfly Orchis (*Habenaria bifolia*), which bears a spike of white flowers sometimes tinged with green. I have also seen one or two specimens of the Frog Orchis (*Habenaria viridis*), but it is distinctly uncommon with us.

But we must not linger over the Orchids just now ; we can give more attention to them another day. The Wild Hyacinths (*Agraphis nutans*) are at the height of their season ; they seem to cover the carpet of the wood with a blue mist. These are not the Bluebells of Scotland, although they are sometimes called "Bluebells." The true Bluebell is the *Campanula rotundifolia,* or the Harebell, which sends up its delicate blue flowers in July, and continues to adorn heaths, fields, and dry banks until September. The flowers are "pendulous"; they hang like little bells. Sometimes a specimen is found bearing white flowers.

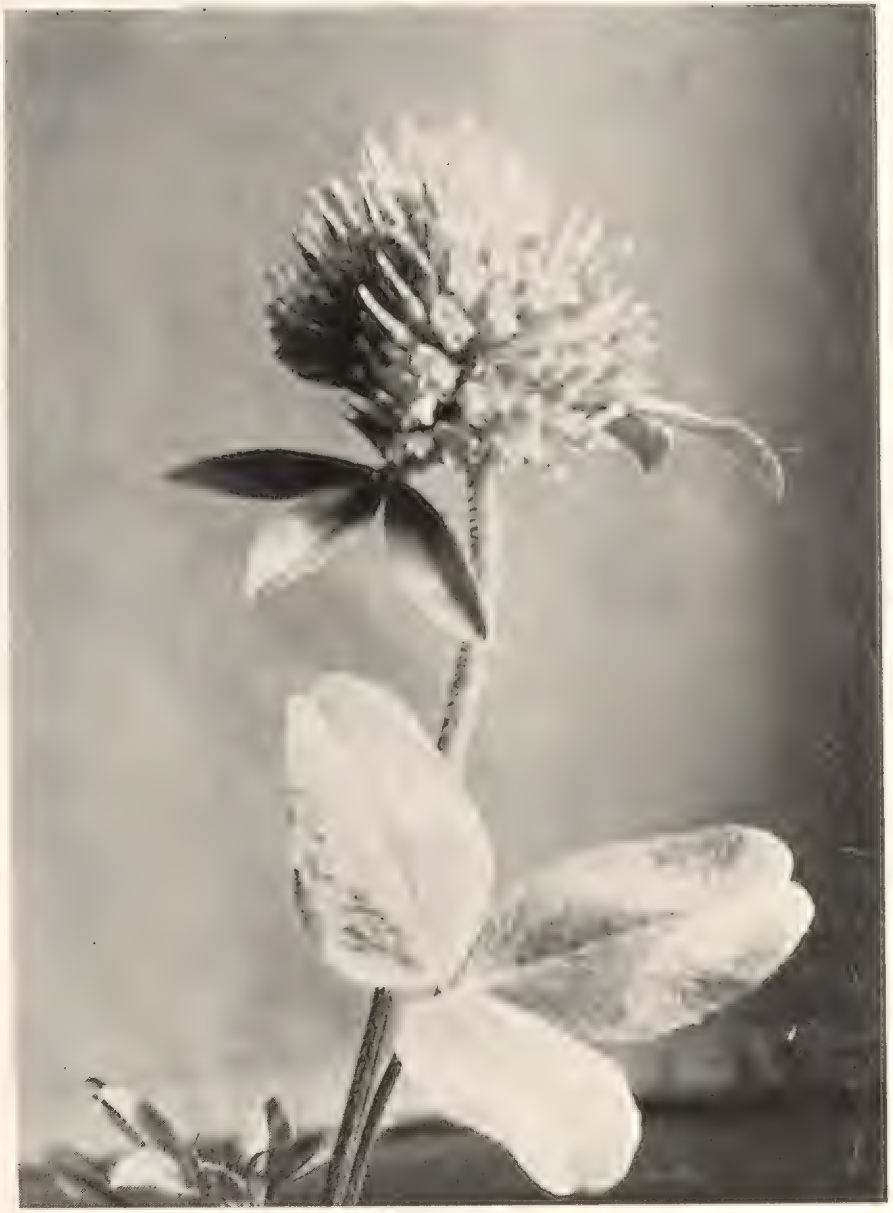
The ditch which skirts the wood is bordered with the Water Avens, growing in the richest profusion. I must gather a few specimens. Why, here is just about as curious a specimen as I have ever seen ! And here is another very like it. I must say I have never chanced to find such a variety of Avens before. We will clap both of them into the vasculum, and deal with them at home. I am almost sure we have found something quite unique. Let us mark the place where we have found these plants, so that we may come back and look for more if necessary.

Are not the woods lovely just now ? This road is an avenue of peace and sweetness on a day like this ! Look out for Squirrels. See, there is one

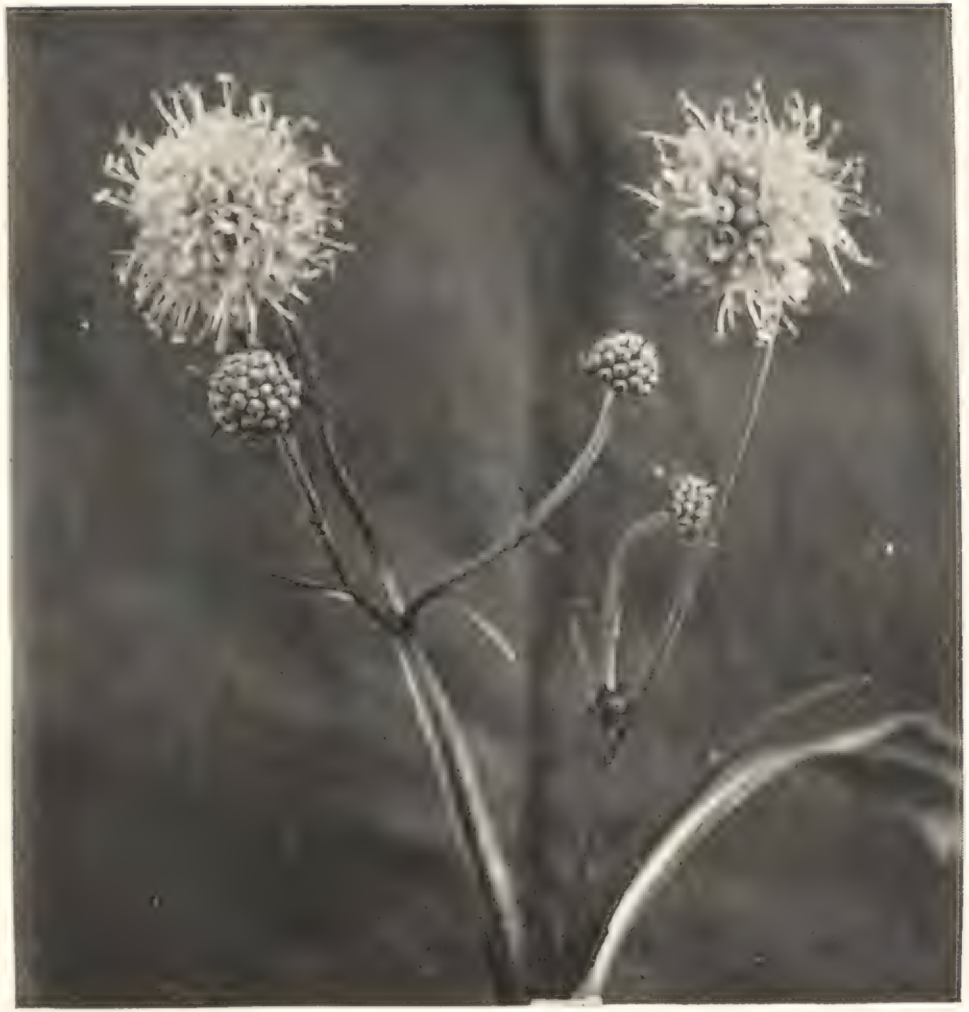
PLATE 50

Trout and Salmon.

PLATE 51



(*a*) Red Clover. *P*. 167.



(*b*) Devil's-bit Scabious. *P*. 213.

right in the middle of the road, sitting on its haunches and chewing at something which it is holding between its front paws. Keep perfectly still and watch. It is moving. Ah! It has caught sight of us and is rushing up that tree. It seems to be dodging us behind the trunk. What a leap! It must have sprung four or five yards in leaping from one tree to the other. Did you notice how its tail was stretched and spread out as it leaped? One might call it a glider as well as a rudder.

The Squirrel is as charming a little mammal as any we possess in these islands. I know of no animal that is more pleasing to the eye or more engaging in its ways. But I do hate to see the little creatures in captivity. It seems an awful thing to take such a denizen of the woods, such a creature as can only be happy in freedom, and confine it in a cage, its only exercise to be found in turning a wire wheel which always reminds me of a treadmill. Wild Nature must be won by kindness, and you can see an exhibition of what can be done in taming animals by sheer kindness and protection in the London parks. Quite recently I was passing through Regent's Park on my way to the Zoological Gardens, and I was delighted with the tameness of the birds, the pigeons, and, above all, the Squirrels. I saw many of these winsome little animals grubbing about quite leisurely amongst the grass under the trees, and some of them made their way on to the broad road, where they were fed by visitors. It was nothing less than delightful to see the animals moving about undisturbed and unconcerned by the traffic. I should like to be on the best of terms with wild Nature, and am always sorry when animals run away from me as if I were their sworn enemy.

Squirrels are little harvesters. They lay up stores for the dark, cold, and fruitless winter. In their nests, which they make high up a tree in some forked branch, or in a hole in the trunk, they stow away nuts, acorns, and other kinds of provender. In very cold weather they sleep in their nests, but a glimpse of winter sunshine wakes them up and makes them repair to their stores for a good meal. Like them we should lay by a store for bad times, so that when adversity comes we may be able to meet it with a smile. And we need mental as well as material provender. A man whose mind is well furnished with good thoughts and moral wisdom can pass through much trouble without feeling hardship; and I think I may say that a good naturalist has a wealth of mental food that will always stand him in good stead. I say with Emerson: "Give me health and a day with Nature, and I will make the pomp of Emperors ridiculous."

A pair of Squirrels will have as many as seven youngsters. These animals, though so charming in their ways, are not always delightful to handle, nor are they so clean as they appear. They are nearly always pestered with numerous fleas, and their nests are verminous.

The Hazel (*Corylus avellana*), from which you will probably gather some nuts in the autumn, is now in leaf; the work of its flowers has been finished for some time. You know the "Lambs' Tails" that appear on the Hazel-bushes in the very early spring—those long, limp catkins which dangle in the wind and shed showers of yellow pollen. The so-called Lambs' Tails are really strings of male flowers. The female flowers, from which the nuts are developed, might be mistaken by the novice for buds. They grow on the same branch as the male catkins, are reddish in colour, and each budlike catkin is really a cluster of flowers, all of which have styles and stigmas. The stigmas, which are red, appear as a kind of feathery tip to the catkins. The catkins of the Hazel appear before the leaves, and this is a very wise arrangement, for the Hazel is "wind-fertilized." The male flowers produce and shed such showers of pollen in order that at least a few grains of it may be carried by the breezes to every female flower; and the female flowers have their feathery stigmas exposed, as already described, so that they may catch some pollen as it is wafted about. Were leaves present while this business is being transacted they would be very much in the way.

I know what you are going to say. You are thinking about another small tree, or shrub, which bears catkins, and which the youngsters call "Palms" or "Pussies' Feet." The "Palms" are the catkins of the Great Sallow, or Goat Willow (*Salix caprea*), which grows in this wood and in other situations about here. There is plenty of it by the side of the brook and in the old part of the quarry. Both male and female catkins of the Sallow appear before the leaves, but the sexes are always borne on separate plants. The male catkins are resplendent with their golden anthers, which shed pollen very freely. The female catkins are quite as conspicuous as the male ; they are not small and insignificantly budlike as in the Hazel, and, of course, each little flower in the catkin bears a stigma, which catches the pollen from the male flowers. Plants bearing male flowers are often some distance from others bearing female flowers, so the Sallow seems to have decided not to depend entirely upon the good offices of the wind in distributing its pollen. The wind helps considerably, but should the wind fail, the Sallow is sure of the services of insects, which visit it freely in the flowering season, and carry much pollen from plant to plant. The Sallow may be seen in fine bloom in April and May ; in good seasons I have seen it as early as March. On bright days in early spring you can observe a busy commerce taking place between it and the bees.

I think the Hazel and the Sallow will never cease to interest us ; they are conspicuous when flowers and woodland foliage are scanty ; we associate them with the spring and regard them as heralds of a leafy spring, a flowery summer, and a fruitful autumn.

What flowering plant could be sweeter to gaze upon than the dainty, fragile little Wood Sorrel (*Oxalis Acetosella*) ; it is so common that everybody knows it, yet not so common as to be treated with contempt. I do not think we shall ever cease to regard this little plant with some curiosity. For one thing, it is associated with the name of St. Patrick, and is commonly regarded as the true Shamrock by which that worthy man used to illustrate the doctrine of the Trinity. Then its delicate ternate leaves fold together at nights and on dark, cold days; they go to sleep, so to speak. The flowers are sometimes pure white; often they are veined with lilac, and occasionally one may find an odd flower that is entirely lilac. Folk say it is lucky to find "four-leaved" clover; I do not know about the luck, but I'm sure it is delightful to find a lilac flower on the Wood Sorrel.

There is an abundance of Bugle (see p. 154) in this wood, and in open patches near the outskirts you may find both the Red and White Campion (pp. 112, 142). But I must call your attention to the Wood Anemone (*Anemone nemorosa*), another member of the Ranunculus tribe. This flower is always abundant in these woods at the same time as the primroses and violets. It is often called the "Wind Flower." The poet refers to it as

> "The coy anemone, that ne'er uncloses
> Her leaves until they're blown on by the wind."

I look upon the Wood Anemone as an illustration of loveliness in humility; its flowers have a drooping habit; they are exquisitely beautiful, yet they humbly and gracefully hang their heads. I like the suggested combination of humility and beauty.

In a few weeks the lovely Tutsan (*Hypericum Androsæmum*) will display its rich golden flowers, to be succeeded later by its red berry-like capsules. I see it is sending out its fine leaves on the bank by the side of the path. I suppose we ought to look upon the Tutsan as a shrub. Its leaves are large and handsome; in the course of time they become tinged with red, when they are exceedingly attractive. This plant, which is by no means common, belongs to the St. John's Wort family, of which we have about a dozen species; it is a relation of the large-flowered St. John's Wort, which is often cultivated as a garden shrub and goes by the names "Rose of Sharon" and "Aaron's Beard." Other members of the family which are commonly seen in our district are the Square-stalked St. John's Wort (*H. quadrangulum*), the Perforated St. John's Wort (*H. perforatum,*) also the Small Upright (H. *pulchrum*) and the Trailing (*H. humifusum*).

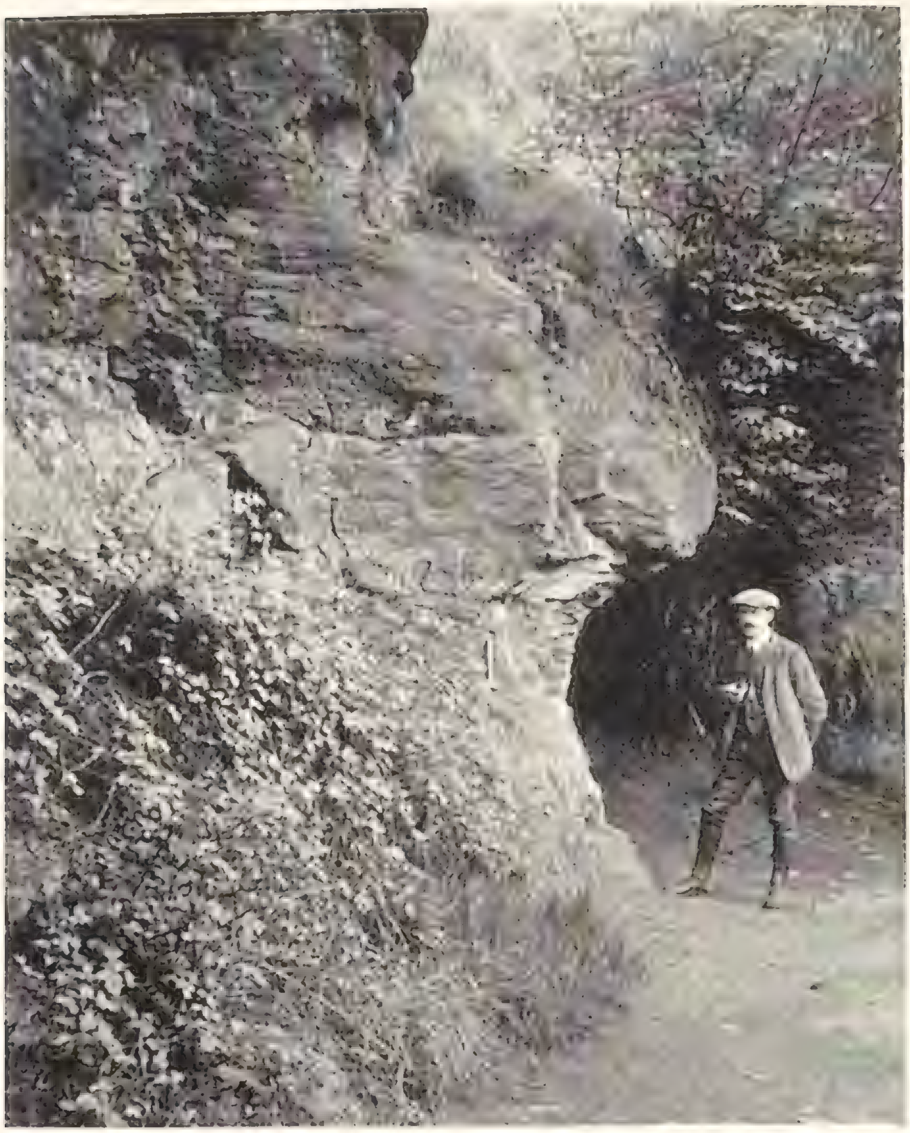
We must not pass the humble little Moschatel (*Adoxa Moschatellina*), which, small as it is, is a close relation of the Ivy, belonging to the same Natural Order—Araliaceæ. Its delicate leaves are scented with musk; there are long stalked leaves rising from the root, and the flower-stalk, which also is radical, bears a pair of opposite ternate leaves near the top. The flower-stalk terminates in a cube-shaped head of five yellowish-green flowers. Four of the flowers are arranged like the faces of a four-faced clock—hence some people have dubbed the plant the "Wee Town Clock"—and the fifth flower is like another clock face on the top of the cube. The corolla of the top flower is cleft into four segments, and the lateral corollas are five-cleft. The stamens are united in pairs. When the flowers have been fertilized and the fruit begins to swell, the erstwhile erect heads begin to hang, and as the weight of the fruit increases, the stalks bearing it gradually bend over until the heads are hidden beneath the leaves. In this way the fruit often escapes the notice of birds ; the ostrich cannot save itself by burying its head in the sand, but the tiny Moschatel is undoubtedly protected by hiding its fruit below the leaves. This "cute" little plant frequents shady places ; it likes damp hedgerows and the mossy ground under trees. The Wood Strawberry (*Fragaria vesca*) protects its fruit in a similar way ; and there is a plant which hides its flowers, which are very small, so cleverly that unless one knew the trick of the plant one would conclude that it did not bear flowers. I refer to the Marsh Pennywort (*Hydrocotyle vulgaris*), whose orbicular peltate leaves are so commonly seen in bogs and marshes.

Observe the strong growth of the Honeysuckle (*Lonicera Periclymenum*) around that small tree. The tree is evidently suffering from the grip of the plant, which has coiled itself around it like a snake, and is throttling it, as one might say. The Honeysuckle, or Woodbine, bears lovely flowers, whose delicious fragrance is well known, but it climbs up to the light and air at the expense of the tree about which it twines its wiry stem. This shrub sends out its leaves very early in the season ; it flowers in July and again in October. The flowers are remarkable for their long trumpet-shaped corollas, at the inner end of which are the nectaries. Only large moths and long-tongued bees can reach the nectar.

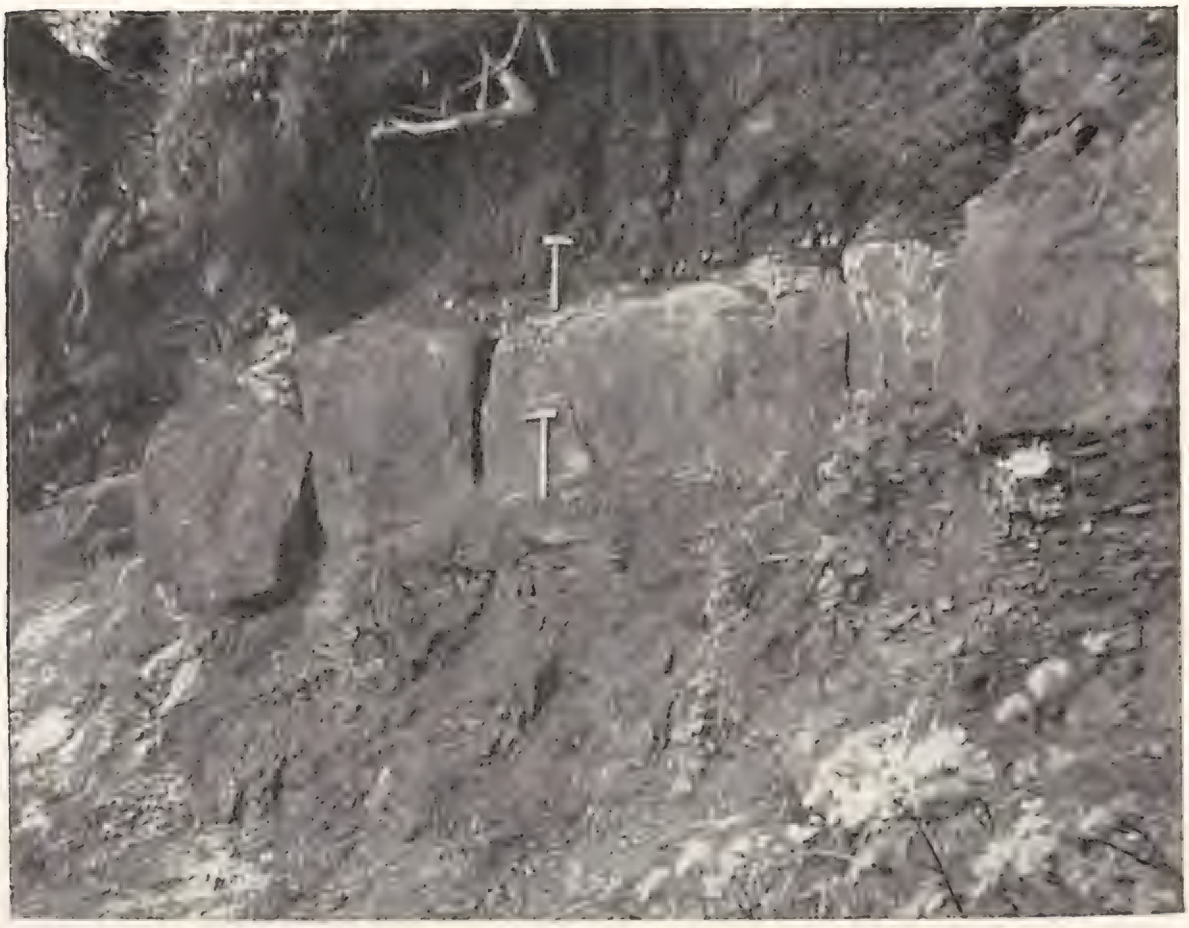
A few Toadstools are in evidence to-day, but the most interesting season for Fungi is the autumn. Then it is that we gather mushrooms from the meadows and a great variety of Fungi from the woods. Let me tell you something about Fungi. What we call Mushrooms and Toadstools are really the fruits of Fungi that lie hidden beneath the soil. The Fungus plant consists of a number of small branching hairlike threads, built up of little cells. There are Fungi which can be studied only with the aid of the microscope. The Fungus threads are instrumental in breaking up decaying matter; they make their way through the substances in which they thrive and extract abundant food for themselves. They break up material—say, for instance, wood—rendering it soft and even powdery; that is to say, they make wood rotten, so that it is easily reduced to dust or pulp, and can fall on to and increase the soil, forming vegetable mould. In this respect Fungi do Nature a service. But they look after themselves in the progress of their work; their main object in life seems to be to increase their kind; and it is to secure this object that they send up fruits, like Mushrooms and Toadstools. The gills of these fruits bear millions of tiny spores, which become scattered about and give rise to other Fungus plants like their parents. You know a Puff-ball is a Fungus, and you have often burst them playfully when they were ripe in order to see the little cloud of dust which is made by the explosion. This dust is composed of myriads of Puff-ball spores. If you lay a Toadstool on a piece of paper and leave it for some time, on removing it you will find the paper is covered with spores which the fungus has shed while lying on it.

Many species of Fungi are edible in addition to the ordinary Mushroom. Every year the Maned

The Path by the Millrace. *P.* 207.



(*a*) Bed of Lava between Beds of Volcanic Ash. *P.* 207.



(*b*) Same as above, nearer view.

Agaric (*Coprinus comatus*) and a close relative (*Coprinus atramentarius*) appear in large numbers in our own garden and provide us with delicate feasts. The Puff-ball, when not old, makes quite succulent steaks, and Warty Caps (*Amanita rubescens*) has an excellent flavour.

The Maned Agaric, or "Shaggy Caps," has a long, cylindrical cap, something like a partly closed umbrella in shape. This cap is covered with a buff-coloured crust, which breaks up into shaggy scales as the fungus expands. The gills underneath the cap are white at first, but they soon turn pink, and are not long before they become black. When a certain stage of development is reached the gills become liquid, and form a fluid which makes quite passable ink. This Fungus should be eaten only when the gills are white or pink.

Coprinus atramentarius is rather like Shaggy Caps, but it bears no scales; the surface of the cap is smooth and of a greyish colour.

"Warty Caps" is globe-shaped when it first appears, but grows until it becomes nearly flat. The surface of the cap is a dingy red, or reddish-brown, covered with little white warty patches. The gills are white, as is the stem. When the flesh of the Fungus is cut or bruised it turns to a reddish-brown.

Although there is a great variety of edible Fungi, you had better not experiment with any that you find unless you are absolutely sure of your species, or you can get the benefit of expert opinion about them. Alas! there are many Fungi that are virulently poisonous, and some of these are so like edible ones that a mistake can easily be made by persons who do not know the finer points of distinction.

Perhaps one of the most attractive of our Fungi is the Fly Agaric (*Amanita muscaria*), which is like "Warty Caps" in shape and in having its cap covered with little wartlike patches. But whereas Warty Caps is reddish-brown on the surface of its cap, the Fly Agaric is a brilliant red. The coloration of a well-grown and fresh Fly Agaric is delightfully gay. But if it is good to the eye it is most certainly bad for the stomach; indeed, it is very poisonous, and must not on any account be eaten.

Our walk through the wood is now ended; we have seen and talked about many interesting objects, but our attention to a few things has diverted us from much that we might have noticed. However, we have done very well, and there are other good days in store for us. I don't think I shall be able to talk so freely as I climb this hill, and, really, I think I had better not tell you too much or you will have mental indigestion.

Dear me! it looks as if we are not going to get over the hill, for there are three subjects for us to consider just where we are. First, there is a colony of larvæ of the Small Tortoiseshell butterfly feeding hungrily on these nettles. They are surely up betimes; we do not usually get them until June. They are very small, so that they have not been long out of their shells. They will feed until they are too fat for their skins, when they will cast them off and appear in a better-fitting garb. Their skins will be changed a few times before they turn into *pupæ* or chrysalides. After a period in the pupa state, the gaily-coloured butterflies will emerge. I propose to take a few of the larvæ home, and feed them in the little cage that I have for the purpose; it will be interesting to watch their development. I will put them into this large pill-box.

In the second place a Mole has been busy just here—notice the mounds of earth it has thrown up, and see the lines of its run. Moles are very interesting creatures; they are beautifully equipped for their mode of existence. The muzzle of a Mole is very muscular and splendidly adapted for boring in the earth; the arms and legs are strong and are utilized in propelling the animal through its bore, as well as in thrusting soil out of its channels; and the hair, or fur, stands up from the body so that the Mole can move backwards or forwards unhindered by its resistance. It is not correct to say that a Mole is blind, although such a statement is commonly made; it has eyes, which although very small, are doubtless serviceable. And I don't think the animal is deaf, even in spite of the fact that it bears no appearance of ears.

The Mole has a curious habitation. It makes long and complicated tunnels, one of them generally leading to water, which the animal drinks very freely; perhaps it needs to wash down the dirt! It feeds upon worms and grubs of various kinds. It makes its nest of grass, fibre, and leaves under one of its larger mounds, and generally has four young. I do not think Moles do very much harm, and in some respects they do good. Their runs and mounds are unsightly, but they consume a number of grubs which are injurious to produce. They are easily caught by placing a trap in the course of their runs. I have seen a cat which was quite expert at Mole-catching. It would watch the runs for hours, and when it detected signs of a Mole's activity, it would pounce upon it with its front feet, which it plunged at lightning speed into the run. But the cat never ate the Moles it caught ; it seemed satisfied with the sport of catching them. Every Mole I have handled has been pestered with a number of well-fed fleas.

In the third place the Yellow Rattle (*Rhinanthus Crista-galli*) is growing freely among the grass. This plant belongs to the Natural Order Scrophulariaceæ, and is thus related to the Speedwells, the Foxgloves, the Eyebright, and the Figworts. It is not at present flowering to the extent it will do a little later. Observe the erect and stiff manner of growth, the loose spike of flowers which have calyces appearing as if they had been blown up with a pneumatic pump. The yellow petals just peep out of the inflated calyx, and one might say the flower bears a slight resemblance to a cock's comb ; perhaps that is why some folk call it the "Cock's-Comb." I suppose the name "Yellow Rattle" has been given to this flower because when the seeds are ripe they rattle loosely in their capsules, after the manner of a baby's rattle. There is a saying among the Swedes that when the seeds rattle in their capsules it is time to gather the hay. It is said that the Yellow Rattle draws part of its nourishment from the roots of the grasses. Thus it is a semi-parasite, living partly by the labour of the grasses and partly by its own efforts.

There can be no doubt that many things are early this year ; the warm spell of weather we have been enjoying has hurried matters considerably. The Small Tortoiseshell larvæ are distinctly early and so is the Meadow Brown butterfly (*Hipparchia Janira*), which is flitting about close at hand. That gentleman is not expected until June at the earliest, and this is May 28. But is it a gentleman ? Let us wait until the insect settles, and then decide. Steady now ! Ah ! now we have it. It has a tawny-orange patch about the " eye " on the forewing ; then it is a lady. The female Meadow Brown is larger and more pleasantly coloured than the male ; but neither can be called handsome, in their coats of sooty brown relieved only by the eye on the forewing in the male and the tawny patch in the female. The larva of the Meadow Brown is green with lines of white along its length, and it has a forked tail. It feeds on grasses. This butterfly is very abundant, and can always be found from June until the end of August.

Hullo ! we have disturbed a Lapwing. It flew away very quietly from somewhere near us here, and now is joining its mate yonder, the pair of them circling about and uttering their melancholy cry. They want us to believe that their nest is where they are ; but I am sure it is quite close to us here. We must find it, for I want a photograph of the eggs. What a pity ! I have actually put my foot on the nest and broken two of the eggs. But two remain, and I will take a picture of them. How slight the nest is, just a little dry grass loosely arranged in a slight hollow of the ground ! The olive-green eggs, blotched with black, harmonize well with their surroundings, and it is easy to pass over them without seeing them. Lapwings, or Peewits, are very common in this district ; I think they are very handsome, with their neat crests, and the manner of their flight is most interesting.

As we climb the hill we cannot fail to notice the golden glory of the Gorse, or Whin (*Ulex Europœus*), which is so well known as to its general appearance that it needs no description. There is no season of the year when some few flowers of the Gorse are not to be seen, but just now it is at its very best. Doubtless people would like to gather the flowers for home decoration, but few attempt to do so ; they do not like the sharp prickles. As it happens, the Gorse would be dainty eating for cattle, but not liking either to be cut or eaten, it has covered itself with sharp spines, which keep its enemies at a safe distance. But it cannot protect itself against fire, and when men want to be rid of it they set it on fire, and thus clear the ground. The Gorse belongs to the Pea and Bean tribe, Natural Order Leguminosæ. It bears its seeds in small pealike pods which open suddenly, with a slight explosion, in hot weather, and in that way scatter the seeds over a considerable area of ground.

But we won't talk any more until we get over the hill and descend to the lovely glen through which the river has made its course.

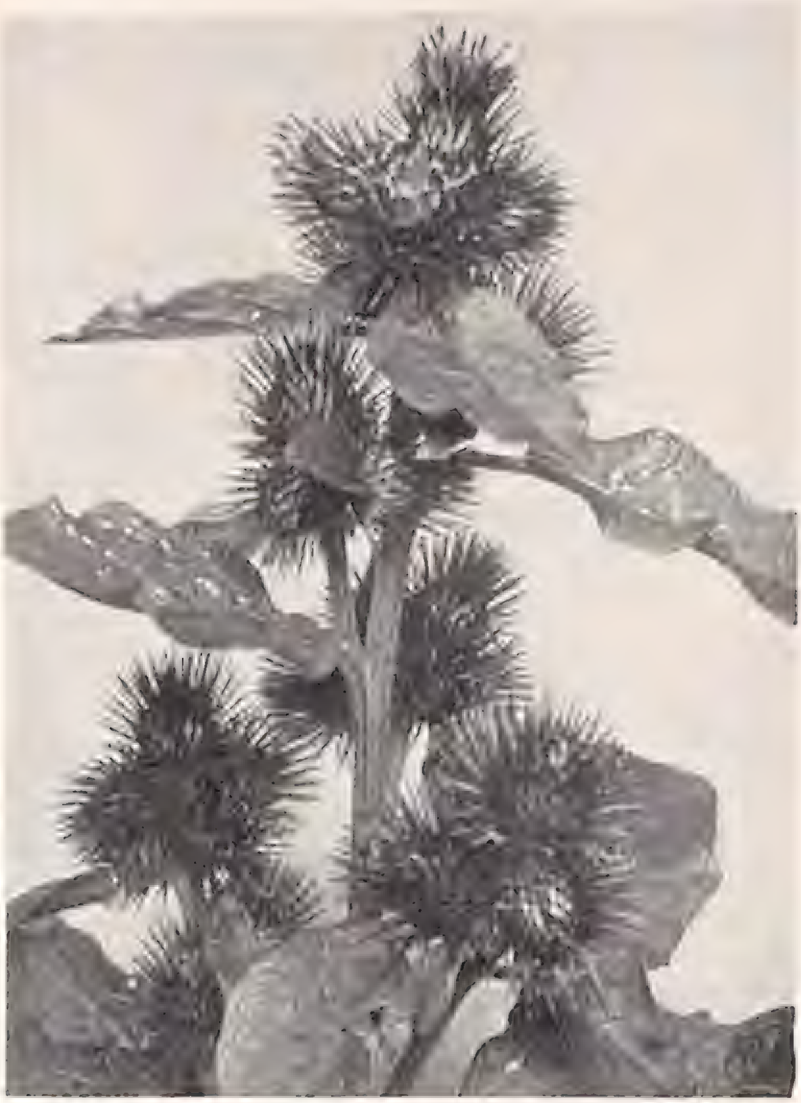
* * * * *

There could be no more charming spot than this. The stream makes its way over a rocky bed, descend-ing in a series of falls to the deeper river, of which it is a tributary, a few miles away. There are deep pools in which the Brown Trout lurk, sweeping shallows, rocky boulders partly high and dry, and bubbling cascades. In parts the stream has literally carved its way through solid volcanic rocks, which now stand cliff-like on either side; in other places farther along it has washed away shales and limestones and opened out a wider course. For ages this stream has been cutting and carving its way; this glen is due to its ceaseless activity. Below us is the stream; between it and the footpath there is a bank of rich vegetation, and on our left is an artificially made millrace, whose waters turn a big millwheel about a mile and a half away.

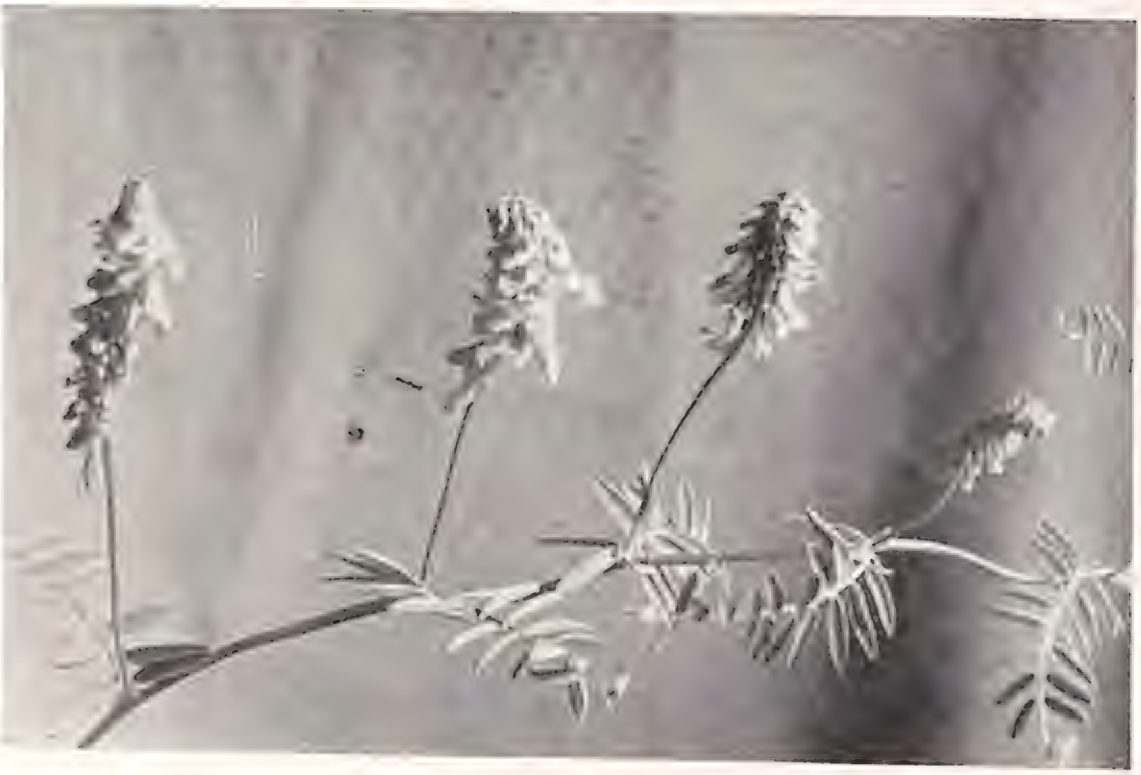
I want you to notice this cliff, part of which is weathering very rapidly. Here is what looks at first like a bed of sand; it is quite yellow and gritty. But it is not sand by any means. On the reverse it is a stratum of volcanic ash about six feet thick. Above it, and jutting out from it, you see a bed of lava about three feet thick. This is solid and hard; it does not weather down so rapidly as the ash. Again, above the lava is another thick bed of ash. The story of this cliff is fairly easily read. The igneous rocks about here are of Lower Carboniferous age, when there was great volcanic activity. The volcano from which this material came first belched forth big showers of ashes, which settled down to form the lower ash-bed; then it sent out a big stream of lava which formed the lava-bed; afterwards it sent out more and yet more ashes. which gradually accumulated and made the upper ash-bed. Why, we can almost image the whole affair in operation!

Down in the bed of the stream there are some "pot-holes." These have been made by whirlpools or eddies which have whirled boulders round and round like millstones. As the boulders turned they gradually wore out circular holes. In that hole there you can see a rounded stone, which was once big and rough, but has been gradually ground down and smoothed to its present size; its whirling, grinding motion has not only caused it to become smaller and smaller, but it has also made the pot-hole in which it lies. The stream is low to-day, and you cannot see the process in action; but after heavy rains the stream thunders down its course, and boulders may then be seen whirling and grinding in the holes. These pot-holes are sometimes called "witches' cauldrons." Notice these two holes that are side by side. The partition between them has been cut through by the grinding action of stones, and a hole has been made at the base of each of them, allowing water to escape into the pool below.

This stream is a favourite haunt of the Dipper (*Cinclus aquaticus*), called in England the Water Ouzel and in Scotland the Water Crow. The Dipper is about seven inches in length. The colour above is dark grey, all the feathers being edged with black; but the bird is well known by its cheeks, throat, and chest being pure white. It is a very shy bird, and, unless in the breeding season, it is usually seen alone. If you desire to watch it you need to hide under cover of a rock or in some other advantageous

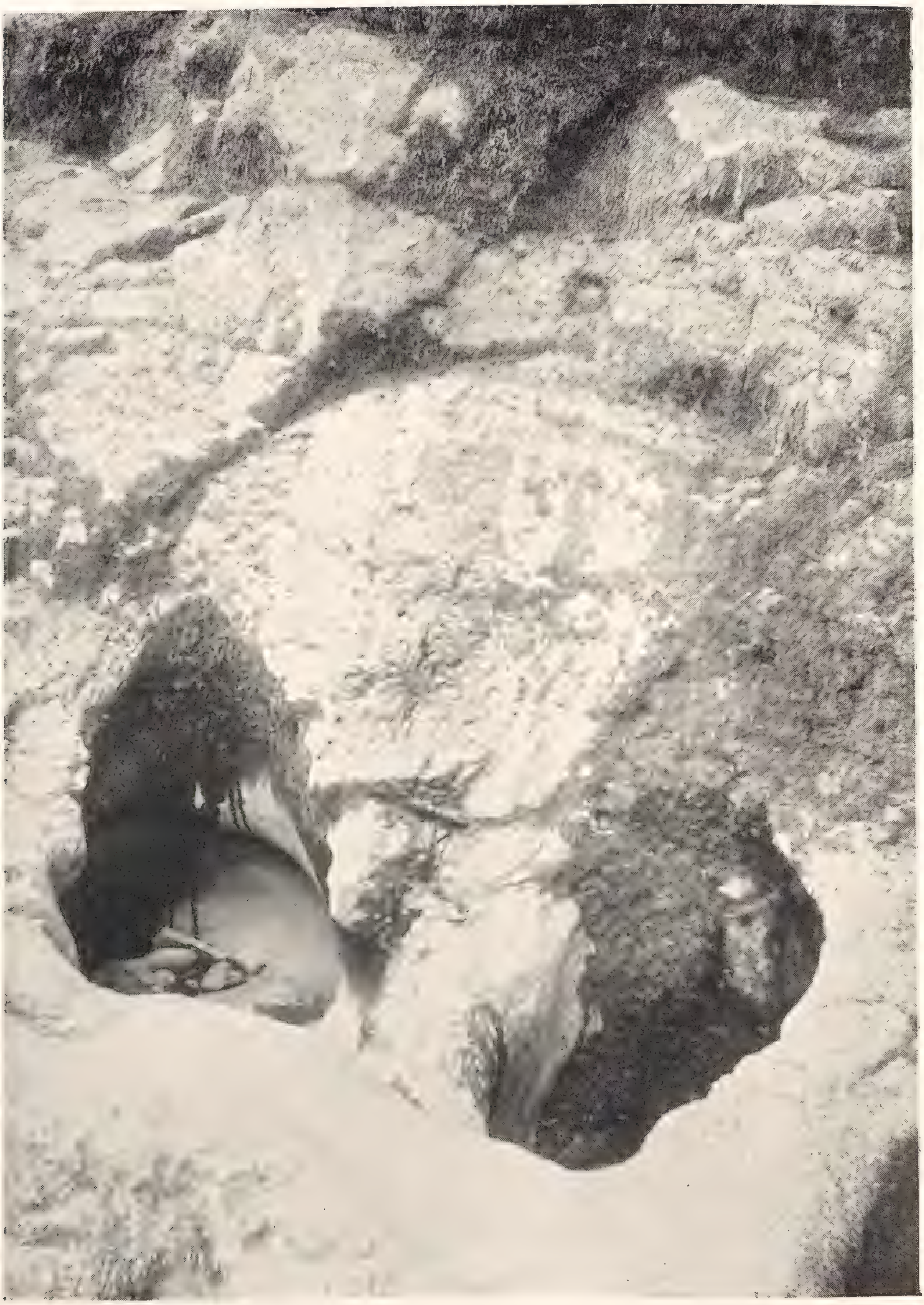


(*a*) Fruit of Burdock. *P.* 232.



(*b*) Tufted Vetch. *P.* 209.

PLATE 55



Pot-Holes. *P.* 208.

position and keep perfectly quiet. I suppose it is called the "Dipper" because it "dips" into water in search of food. Sometimes it walks into a stream; at other times it plunges suddenly and disappears below the surface. It makes a big mossy nest in the cleft of a rock or under the roots of a tree by the water-side. It lays four or five pure white eggs.

The Yellow Pimpernel, or Wood Loosestrife (*Lysimachia nemorum*) is growing plentifully on the bank underneath the trees and shrubs. This is a member of the Primrose tribe (Primulaceæ). Observe its trailing stem, its small, opposite, egg-shaped leaves and solitary axillary flowers, which have five yellow petals. A charming little flower. I might mention two other Pimpernels belonging to the same Order—*Anagallis arvensis*, the Scarlet Pimpernel or Poor Man's Weather Glass, which grows in cornfields and gardens, and opens its beautiful little scarlet flowers only in fine weather; and the Bog Pimpernel (*Anagallis tenella*), a very slender plant bearing pink or rose-coloured flowers. As its name implies, the Bog Pimpernel haunts boggy ground. It is a really elegant little plant, and you should look out for it.

The Vetches, which are members of the Pea and Bean tribe, are usually well represented on this bank. Here is the Bush Vetch (*Vicia sepium*), bearing its pinnate leaves terminated by tendrils and its clusters of from four to six bluish-purple flowers. The Tufted Vetch (*Vicia cracca*) has smaller leaflets and more flowers, which are blue and crowded on to one-sided spikes. I see the plant growing healthily, but its flowers will be a few weeks before they appear.

The rocks on either side of the stream are now of a different kind, and the valley opens out more widely, the scenery becoming more pastoral. We have left the volcanic region, and are amongst shales, limestones, and sandstones, still of Carboniferous age, but more recent than the ashes and lavas we have left behind us. These rocks belong to a higher horizon than the lavas, but they have been faulted down to such an extent that they now lie lower than the volcanic series. We had better use the geological hammer among the limestones, secure a few fossils, and then make our way home. I am tired and hungry, as I think you are, and we have seen enough to-day to set us thinking and inquiring for a long time to come.

CHAPTER X

A RAMBLE IN MAY: THE EVENING AT HOME

Now that we have washed and eaten, and feel "like giants refreshed," we can settle down to a little pleasant work and conversation.

I have placed the Small Tortoiseshell larvæ in the breeding-cage, given them plenty of fresh nettles to consume, and they are feeding as happily as can be. We must take care that they are supplied with fresh food every day.

Before we do anything else, we must examine those remarkable specimens of Avens. Now that we come to examine them closely, what beautiful flowers they are! They look almost like Roses. The Water Avens bears drooping flowers; its relation, the Herb Bennet, holds its flowers erect. These specimens, which are certainly neither Water Avens nor Herb Bennet, hold their heads upright. Let us see what "Johns" says. On p. 79 he describes the features of the genus *Geum:* "Calyx ten-cleft, in two rows, the outer division smaller; petals, five; styles finally becoming jointed, awns hooked at the extremity. Name from the Greek, *geyo*, 'to taste.'" Thus an orderly *Geum* ought to have a ten-cleft calyx in two rows and five petals.

In describing *G. rivale* on p. 85, "Johns" says: "The calyx is deeply tinged with a dull purplish hue with darker veins." Well, our specimens do not answer to this description. In both the calyx is green and leaf-like; but it is certainly ten-cleft, for there are five large leafy sepals and five small ones, all united at the base. And as to the petals, which in *Geum* ought to be five in number, there are actually eleven in each of our specimens. On p. 84 of "Johns" we find this note: "A variety (*G. intermedium*) is sometimes found which partakes of the characters of both the above species (*G. urbanum* and *G. rivale*). It is probably a natural hybrid between the two." This helps us a little, and I am confident our specimens are *G. intermedium*, or the Intermediate Avens, but it is a pity "Johns" does not give a full description. Bear in mind, members of the genus *Geum* ought to have five petals, whereas our specimens have eleven.

There can be no doubt about it; these flowers are "freaks" or "sports." They have broken away from the habits of their kind—"kicked over the traces," as it were—determined to be something different from their brethren. Probably they are tired of the old ways and desire a revolution. Why should they be bound by custom? Our specimens are like a few men of genius who think new thoughts and establish new customs. One thing is certain, in point of beauty our "freaks" are much lovelier and larger than their orthodox relations.

But we must not lay them aside yet. Let us examine the stamens through the hand-magnifier. Ah! now I begin to understand our revolutionary friends a little better. In this specimen there are no less than three small petal-like growths, each springing from the anthers of a distinct stamen; and, in addition, there is one badly-grown petal in the line of the stamens. And in our second specimen we see similar growths. These flowers are beginning a revolution in the ways of their genus by making their sepals leaf-like and some of their stamens petal-like. It is the transformation of stamens into petals that accounts for their irregular numbers. I must tell you that it is not uncommon for stamens to be thus transformed. All Roses once were single; they had five petals and numerous stamens; but they exhibited tendencies to "sport," and rose-growers encouraged them. "Double" Roses are "singles" with stamens converted into petals.

Perhaps our *Geum intermedium* is a new species in the making. It will be interesting to see if the plants produce similar flowers next season, and whether they will exhibit any more freaks. One cannot help wishing that such rank heretics and bold adventurers in the plant world should succeed in their revolutionary measures. But, alas! like many adventurers, they are likely to be crushed.

"Freaks" or "sports" in plant-life are frequent. Clover should have ternate leaves, but occasionally "four-leaved" clover is found, and superstition saith that the finder will be lucky. Perhaps you know the bonny Premorse, or Devil's-bit Scabious (*Scabiosa succisa*), that spangles the pastures with its blue globular heads of flowers in the late summer and autumn. I have sometimes found specimens of this Scabious with two other flower-stalks, bearing flower-heads, springing right out of the ordinary heads. In the *Agricultural Economist* for June, 1910, there appeared a drawing and description of some Primroses whose sepals had developed into large leaves. Botanists contend that all the parts of a flower have evolved from leaves ; that even stamens and pistils are modified leaves ; so if such be the case we need not wonder at floral parts occasionally reverting to a leaf-like condition.

I almost hesitate to get out the microscope, lest we should be tempted to stay up too late ; the hours fly by very rapidly when we study the " marvels of the minute." Perhaps of all subjects for microscopic examination none are more fascinating than living creatures such as we shall have collected from the pond to-day. Beautifully mounted specimens are always interesting, but when we get living things that move and show us the manner of their little lives, they fascinate us with the wonders of their ways. Well, here is the microscope, and here are the tubes of material ; let us make a beginning.

We will start with a Water Flea. I catch one by means of this little piece of glass tubing, which is drawn out to a fairly small aperture at one end. I place my finger over the wide end, insert it in the vessel containing the fleas, remove my finger, and the water rushes into the tube. Yes, there is a flea in the tube. I replace my finger, withdraw the tube containing the flea, and by again moving my finger deposit the lively gentleman in this " live cell," allowing him a little water to move in, and draining away the surplus. Now I cover him with the glazed lid of the cell, and he is ready for examination. A low magnification is sufficient.

He is now well in focus, and making lively efforts to get out of his prison. That little fellow, in Nature, is hardly more than a sixteenth of an inch long, but under even a low power of the microscope he looks quite monstrous and formidable. You can make out his parts; they show up distinctly. Notice the small head, which appears to be beaked, and bears two pairs of branched feathery *antennæ*, or "feelers," which the creature flourishes ineffectually in his cell. Then look at the eye; this is rounded and consists of something like twenty lenses. Of course, he has a mouth, which bears a lip, has two mandibles and a pair of jaws.

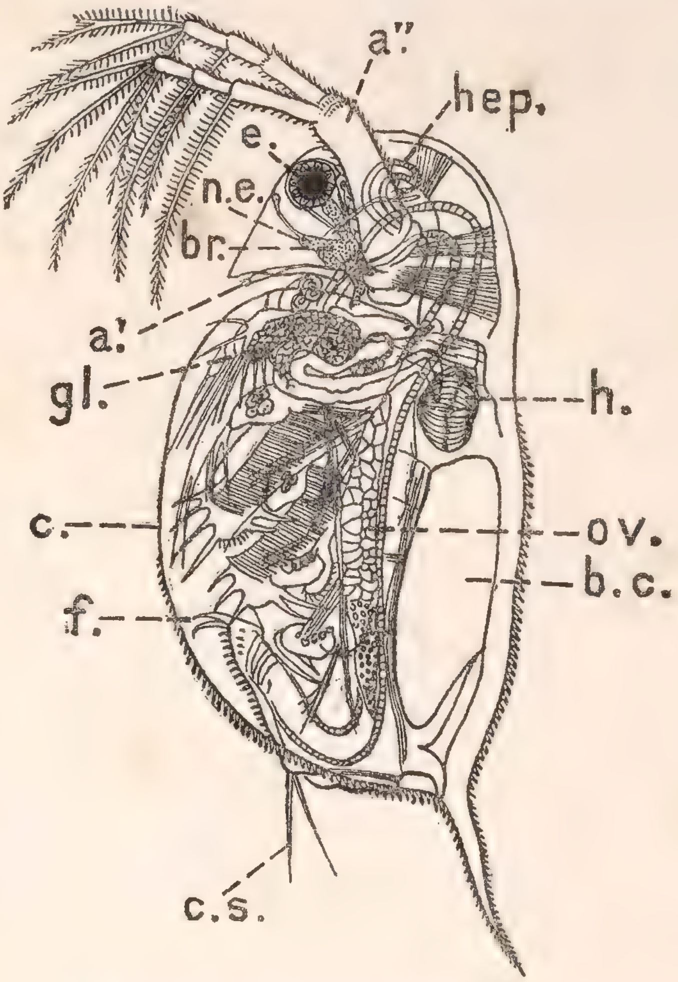


Fig. 56.—Female Water Flea (Daphnia pulex).

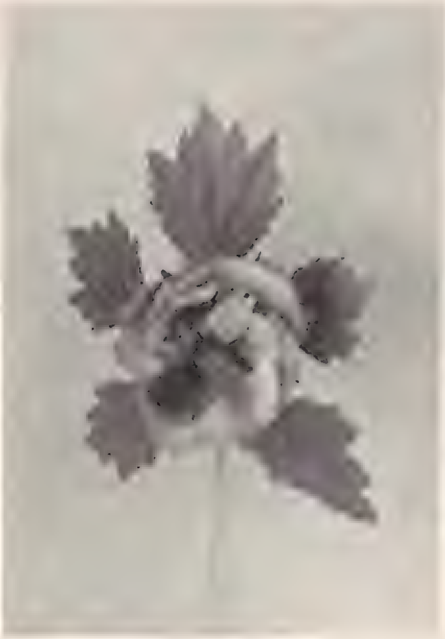
a.", antenna; *b.c.*, brood chamber; *e.*, eye; *h.*, heart.

You have no difficulty in examining the creature's body; it is quite transparent, and you can see all his "works" distinctly. It is a big lower body in comparison with the small head. Observe the kind of pumping, expanding, and contracting organ; that is the heart. You can feel the beating of your own heart, but the palpitation of the Water Flea's can be seen! That darker organ turned upwards at the extremity is the stomach. Our specimen is a male; perhaps we can secure a female, in which event we may be able to see the eggs, which are often to be observed filling a space in the lower body towards the back. The Water Flea has five pairs of legs, and his body is protected by a delicate shell.

I am sure you will agree with me that you have before you a well-organized creature, one exquisitely adapted to its mode of existence. Its shell makes it an "armoured cruiser," and its organization shows it to be fairly high in the scale of creation. Perhaps you think it interesting for the animal to be transparent, and consider it might be an advantage if we could see the organs of our own bodies so clearly: certainly we should be better able to tell when there was anything wrong with our "works"! But if we cannot be transparent in body, we can have clear minds, in which we hide no mean motives and wrong thoughts.

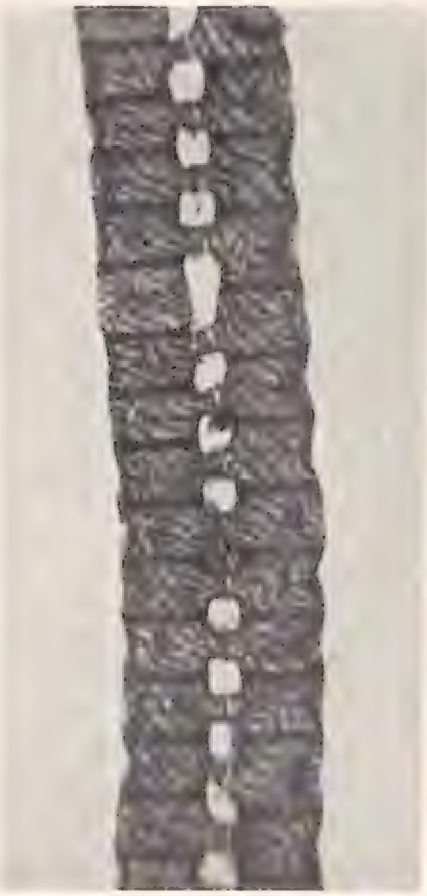
To be correct, the Water Flea is not a flea; it is a Crustacean, allied to the crabs, and of the crab fellowship. It has been called a flea because of the jerky, flealike manner in which it propels itself through the water; it seems to progress in a series of jumps. Our specimen is the common Water Flea (*Daphnia pulex*); several other species are to be found. The Water Fleas live in fresh water, and

(*a*) Butterwort. *P.* 226.



(*b*) "Freak" Avens. *P.* 211.

(*c*) Great Wild Valerian. *P.* 184.



(*d*) Spirogyra in Conjunction.
P. 225.

PLATE 57

An Otter surprised by a Fox. *See page* 233.

they like stagnant ponds. They are to be found in suitable situations at almost any time of the year.

Let us ferret about in our tube, and see if we can find another fresh-water Crustacean of microscopic proportions—I mean the *Cyclops.* I suppose you have heard of the fabled giants, having a single eye in their foreheads, who received the name Cyclops ? The little fellow we are looking for is far from gigantic in his proportions ; he is no bigger than a Water Flea, but he is like the fabled Cyclops, in that he has one eye in what might be called his forehead. Ah ! I have him ; now you can see for yourselves what he is like.

Cyclops has a very different form from that of the Water Flea ; it has not such an "aldermanic corporation." The body is long in proportion to its breadth, and may be described as pear-shaped. The creature has two pairs of antennæ—one large and one small ; also five pairs of shortish legs, by which it jerks itself rapidly through the water. In the Cyclops community the females greatly outnumber the males. The females are easily known by the pair of ovary sacs, or egg-bags, which hang one on either side of the lower part of the body. One female has been observed to lay eggs ten times in succession ; it has been calculated that if eggs are deposited at the rate of forty a time eight times in three months, in the course of a year a single female may be the progenitor of about four thousand millions of young. That is to say, one female would give birth to three hundred and twenty young in three months, and, supposing two hundred and forty of them to be females, they in turn would yield other young, and so on. At this rate of reproduction, which is a very moderate estimate, one would expect Cyclops, small as they are, to fill a pond in a very short time ; but these animals have plenty of enemies in their native haunts—enemies who consume them wholesale, and thus maintain the balance of Nature.

I have been looking in our tubes for a creature that can demolish both Water Fleas, Cyclops, and even small Worms, but I'm afraid we have not secured a specimen ; so you will have to be content with a description, and live in expectation of capturing one another day. I refer to the Hydra.

The Hydra is an animal of a most astonishing kind, possessing an almost superhuman vitality. A good specimen may be nearly an inch long, so it can be observed with the naked eye ; but its details are observed more clearly when examined with a hand-magnifier, or under a very low power of the microscope. Three species of Hydra may be found —the Green (*Hydra viridis*), the Orange-Brown (*H. vulgaris*), and the Brown (*H. fusca*). What I have to say applies particularly to the green species. The creature seems to have a body of a green jelly-like substance. It attaches itself by a foot to water-weeds. Its body is tubelike, or cylindrical, surmounted at the head by some six or more arms or tentacles arranged in a starlike manner. At the end of the tubelike body, and surrounded by the tentacles, is the mouth. When the animal is active it stretches its body to full length, and waves its tentacles in all directions in the effort to secure food. If anything good to eat—say a Water Flea or Cyclops —comes within reach of the tentacles, it is seized and thrust into the mouth, to be digested in due course. When not feeding, or when alarmed, the animal may be seen to have collapsed into what may be termed a shapeless mass. Careful examination shows that the body and tentacles of the Hydra are covered with little lumps, like warts or pimples. These are cells containing stinging threads, which are forcefully emitted as occasion arises, and are used to disable prey.

But the story of the Hydra is not yet told; the most wonderful part of it is to come. The creature can be turned inside out, and yet live and thrive, being able to capture and digest food even in what we should think to be a most uncomfortable condition. Cut the body into two, and each half will shortly become a perfect whole. If you think you can kill Master Hydra by cutting him into piecemeal, you may be disappointed; divide him into twenty, or even twice twenty, portions; each portion will develop into a complete Hydra. Cut up each new Hydra in a similar manner, and each piece of it, too, will become a Hydra. If you slit the gentleman lengthwise nearly to the foot, the two sections will grow together, and the astounding creature will shortly carry on his business as if nothing extraordinary had happened. On the other hand, if you slit him from the foot nearly as far as the mouth, you will have one head with two bodies. Cut off the tentacles, and new ones soon come to replace them, while the tentacles you have removed will grow into separate Hydras. Thus you actually increase the number of Hydras by cutting them up. As likely as not, if you cut a notch into the body of the animal, a young Hydra will bud out of the notch.

Budding is a common method of reproduction of these creatures. Young Hydras may be seen budding out of the bodies of their parents, sometimes two or more at a time. First a little bud appears on the body ; it develops rapidly ; tentacles grow on the youngster at great pace, and it is not long before the young hopeful is feeding heartily while still attached to its parent's body, and even contending with the old one for dainty bits. In the winter, Hydras produce eggs which grow into perfect animals in due course. So, you see, these creatures have a wonderful capacity for reproduction. They may, in the first place, produce young from eggs ; secondly, they give birth to them by budding ; and thirdly, if the parents' bodies are accidentally cut into pieces, each piece will become a complete animal.

These little denizens of the pond remind us of the famous Hydra of Greek mythology. That monster, you will remember, is said to have ravaged the district about Lake Lerna ; it is reputed to have had a hundred heads, and if one head was cut off two others came in its place. It was the renowned Hercules who put the monster out of existence. I do not suppose such a creature ever existed, but I know that human selfishness is a Hydra-headed monster, destructive of peace and goodwill among men ; it is a monster difficult to dispose of ; like the Hydra of the myth, it has a way of growing two heads in place of one that we remove. It is only the noble manhood, represented by Hercules, that can dispose of it.

To us, the Hydras of the pond are insignificant, but if we can put ourselves in the place of Water Fleas, and small fry of that kind, we can faintly imagine that the Hydras are monsters from their point of view—monsters no less terrible than that described in the Greek story. In the classification of animals, Hydras are placed in the sub-kingdom *Cœlenterata;* they are thus related to the Corals, Sea Anemones, and Jellyfish.

I want you to look at the animal I have just taken out of this tube and placed under the microscope. It is the common Rotifer (*Rotifer vulgaris*), or, as some call it, the "Wheel-animalcule." It gets its name (*Rotifer* = wheel-bearer) from the two discs above the mouth, which seem to be rapidly going round like wheels. This circular motion of the discs is not actual, only apparent. The expanded discs are surrounded with very fine hairs, or *cilia,* which are in continual motion when the animal is feeding. Their motion makes a little vortex, or whirlpool, in the water, and by this minute creatures in the water are sucked in and impelled into the mouth below. This species of Rotifer is a common inhabitant of ponds. Notice its cylindrical form, and the mouth and internal organs, which can be easily seen through the transparent body. When feeding, or at rest, the Rotifer attaches itself by a sucker-like foot to

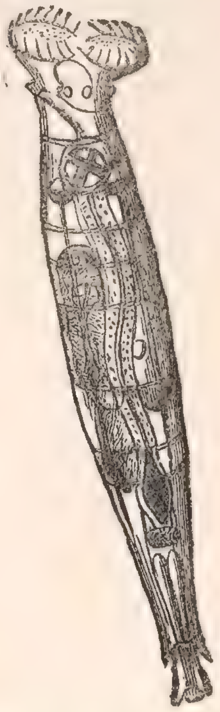


FIG. 57.—THE "WHEEL-ANIMALCULE," OR COMMON ROTIFER (ROTIFER VULGARIS).

some water-plant. It can readily detach itself from any site it occupies, and travel about by looping its body, somewhat after the manner of a caterpillar, using its foot and proboscis in the operation, in the place of ordinary legs. This animal is found in many situations—ponds, gutters, puddles, and even amongst conferva on damp walls.

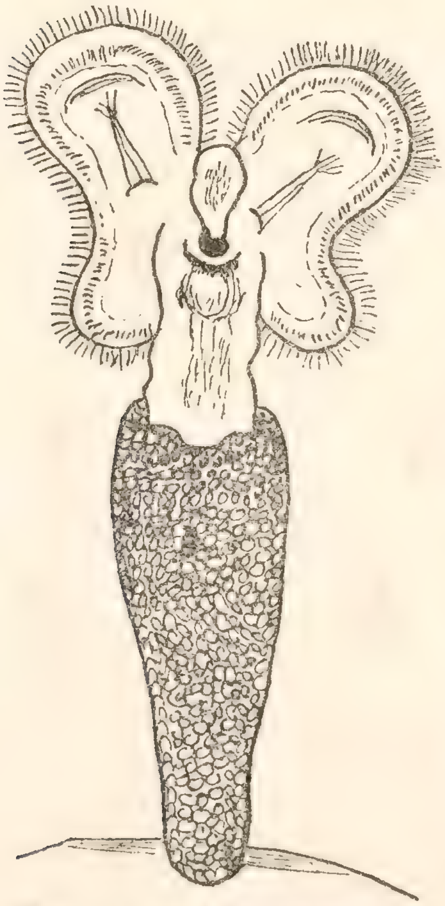


FIG. 58.—MELICERTA.

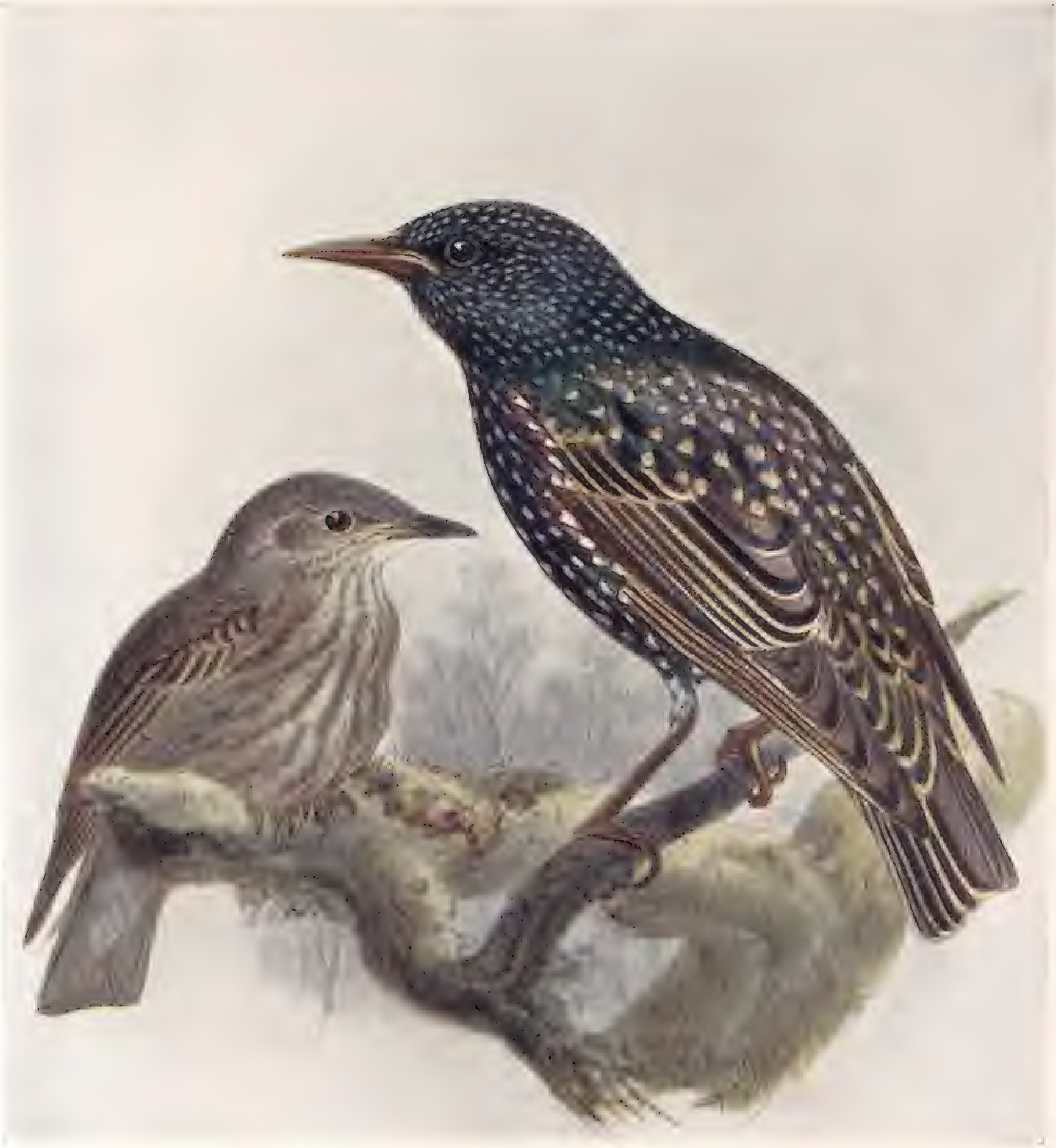
One of the most marvellous of the several kinds of Rotifers is the *Melicerta.* You have seen the little tubes made of bits of rushes, stick, fibre, seeds, grains of sand, and other materials which are occupied by the clever little larvæ of the Caddis Fly; and I have no doubt you have often found on the seashore the wonderful little tubes, made of cemented shell particles and grit, in which the worms called *Terebella* make their homes. Now, the Melicerta, which is not more than a fifteenth of an inch in length, is a builder equally as clever as the Caddis Worm or the Terebella. This Rotifer finds a suitable site on the leaf or stem of some pond plant, on which it erects its permanent home. It makes very tiny round pellets, which it lays around itself in a small circle. Pellet after pellet is made, laid, and cemented to the others, until a tower-like tube is built. In this tube the Melicerta resides, like a king in his stronghold. When in repose, or alarmed, the animal contracts into the space within the tube, but when feeding it expands its body, which opens out about the mouth like the petals of a flower. Each petal-like " process " is surrounded with cilia, or fine hairs, which move and create a vortex in true Rotifer fashion. Unless the habits of this animal were commonly observed and the facts constantly verified, we could hardly imagine or credit such a tiny creature being endowed with such constructive ability.

The time is passing only too rapidly, but we have yet to examine some Diatoms which I had the fortune to get amongst the mud I gathered in this tube. We are piling wonder upon wonder. Did you ever see such a remarkable object as that which is now gliding about under the microscope ? Ah ! there are several of them, all of the same species. They travel like tiny ships, and can reverse their engines more rapidly than can be done in any boat. Our specimens are *Navicula* (*i.e.*, little ships). They are very, very small, and need to be magnified greatly in order that we may see their details.

Now, what are Diatoms ? Are they plants or animals ? Seeing that they move about so easily, I suppose you would vote them animals. But, in reality, they are plants. They are *unicellular*, or one-celled organisms ; the brownish colouring matter you see in them is allied to the colouring substance of ordinary leaves, known as " chlorophyll." The living substance of the Diatom is enclosed in a kind of shell of flinty material, which is known as the "cell-wall." This shell is of two valves, which are as a box and its lid. A slimy secretion covers the outside of the cell-wall, which I have likened to a shell, and this enables the Diatom to slip about so easily. There are many species of Diatoms, each one having peculiar markings on its flinty cell-walls. One might imagine these markings to be the work of a skilful engraver. Diatoms are further examples of Nature's armoured cruisers. We have talked of armoured fish, and other armoured animals; now we find examples of armoured plants! Nature never ceases to surprise us.

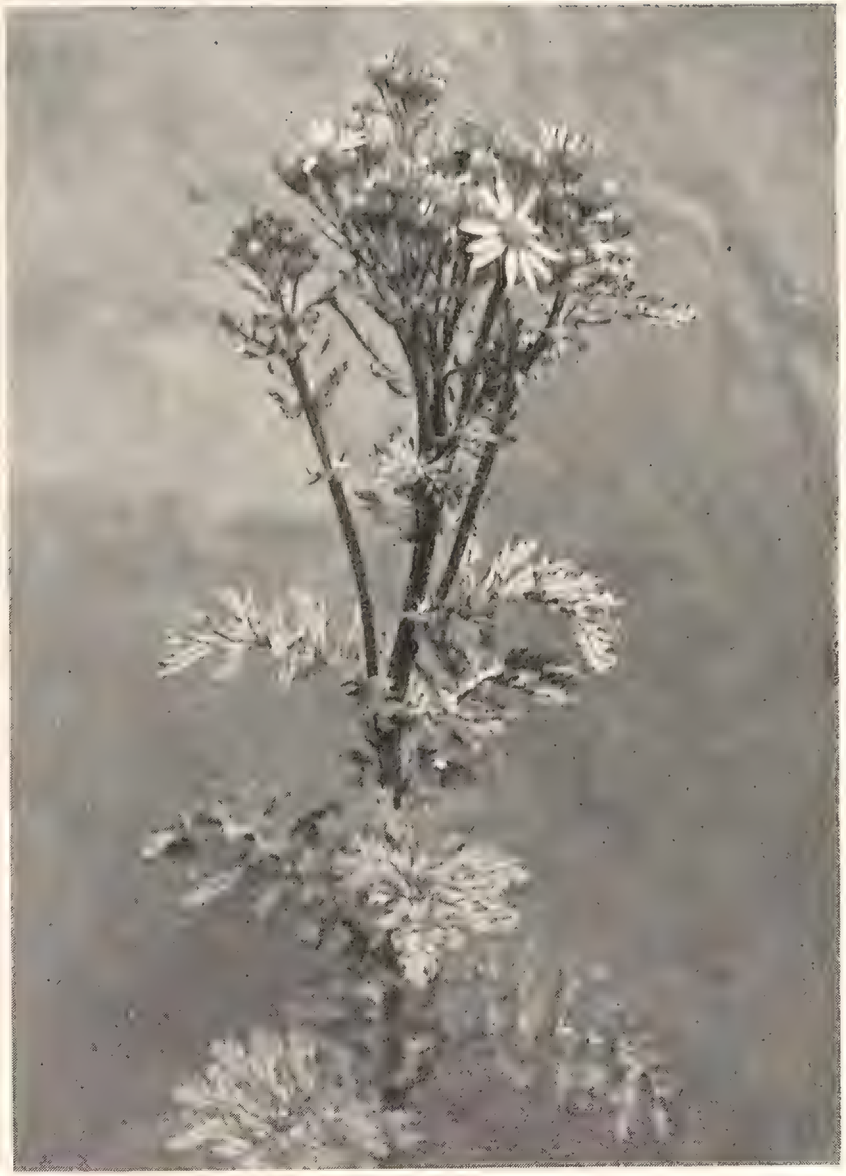
These little plants multiply by division, each one becoming two. They are interesting to geologists as well as botanists, for their flinty skeletons fall to the bottoms of lakes and oceans, and form deposits known as "Diatom-earth." A bed of such material occurs at Richmond, Virginia; it is no less than thirty feet thick; so you can imagine the immense period of time it would take for such a deposit to be made. Diatom-earth is also found under peat-bogs in some parts of Britain.

I must mention another plant that propels itself through water, and makes a most interesting object for microscopical study: this is the *Volvox*, which is often found in great numbers in clear ponds. This organism is scarcely more than a fiftieth of an inch in diameter. It is a tiny globe of green membranous matter, quite transparent, enclosing a few cells like itself, though, of course, smaller. The little sphere is covered by groups of cilia, and each cell contained within it has a similar covering. The parent sphere propels itself through the water in a revolving motion, and the enclosed cells revolve inside the

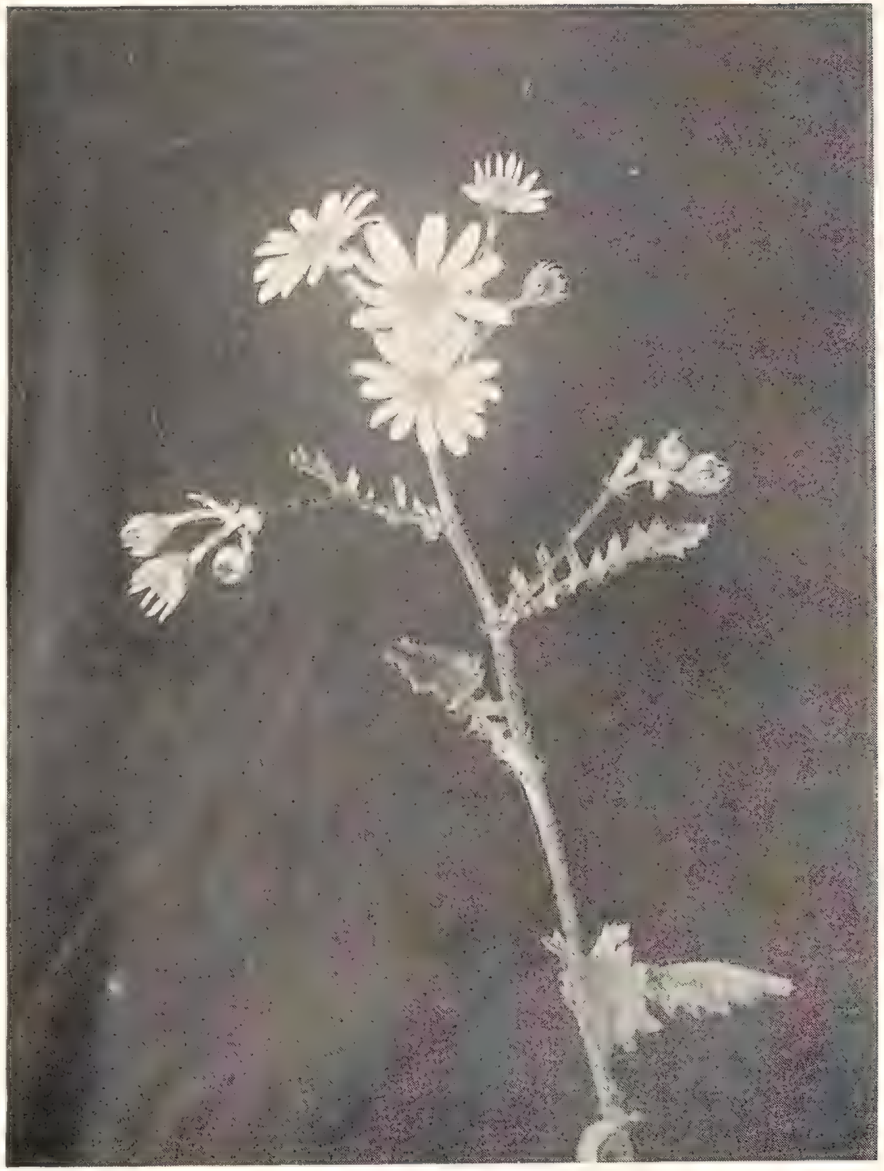


STARLINGS. *P.* 241.

PLATE 59



(*a*) Common Ragwort. *P.* 232.



(*b*) Marsh Ragwort. *P.* 232.

parent cell. This, surely, is a case of "wheels within a wheel." In time the parent cell breaks up, setting free the enclosed cells, which become full-sized, and in their turn give harbourage within themselves to new cells.

Before we set aside the microscope, I want to examine the green, scumlike conferva that I gathered to-day.

As I expected, we have specimens of the green Alga called *Spirogyra.* This weed is a very lowly plant. It grows in threadlike lengths, which may be less than an inch in extent, or upwards of a yard. In running streams it may be seen hanging from weeds in long streamers, but in still waters it grows independently, and appears like a kind of scum. It may be got in cattle-troughs by the roadside—in fact, almost anywhere where water is allowed to stand for any time. Each thread is composed of a number of single cells placed end to end. Under the microscope, as you observe, the chlorophyll, or colouring matter, appears to be arranged in delicate spiral bands which are rough on the edges. Each band is relieved by frequent spots of a brighter green, and in each cell a central body, or nucleus, of living matter is evident.

We have been fortunate enough to secure two threads of Spirogyra in what is called a state of conjugation. You see them quite distinctly. The two threads have come together ; the cells have put out little processes by which the threads have joined, and the joined processes look almost like the rungs of a ladder. In these threads the cell contents have lost their ordinary appearance ; the chlorophyll grains are no longer in spirals. What is going on? Well, the cell-walls are being absorbed, and a way is being made for the contents of the cells of one thread to pass into the cells of the other. By-and-by the combined cell contents will form spores, and from these spores new plants will develop. Thus, you are seeing the mechanism of growth at work. But, although you can see and understand the process of growth, you have no knowledge of the force that sets it agoing. With all our knowledge, Life is as great a mystery and a miracle as ever.

What a remarkable instrument a microscope is! What wonders it discloses! With its aid the field of natural investigation is tremendously enlarged. Once we have had a glimpse of its revelations, we feel we can ill afford to go without it.

Are you still wideawake? I should have thought our day's walking, talking, and thinking would have sent you to the "land of Nod" long ago. Just a little more talk, and then to bed.

When we were out to-day we overlooked the Butterwort (*Pinguicula vulgaris*), which grows in damp parts of the quarry. It was not in flower, for its flowers should not appear till well on in June; but we ought to have noticed its pale green leaves, which grow in little rosettes almost flat on the ground, or in damp clefts of the rock. An inexperienced person might mistake its flowers for well-grown violets on stiff stalks. The flower-stalks rise direct from the roots, and bear no leaves. Each plant produces from one to three or four flowers, which hang from the curved ends of their stalks in a nodding fashion. The Butterwort belongs to the Natural Order Lentibulariaceæ. Perhaps the statement made by the botanist Lindley helps to explain the origin of its common name. Lindley wrote: "The common Butterwort has the property of giving consistence to milk, and of preventing its separating into either whey or cream. Linnæus says that the solid milk of the Laplanders is prepared by pouring it worm from the cow, over a strainer on which fresh leaves of *Pinguicula* have been laid. The milk, after passing among them, is left for a day or two to stand, until it begins to turn sour; it throws up no cream, but becomes compact and tenacious, and most delicious in taste. It is not necessary that fresh leaves should be used after the milk is once turned; on the contrary, a small portion of this solid milk will act upon that which is fresh in the manner of yeast." We must try an experiment on these lines one of these days.

The Butterwort, however, is an interesting plant in another respect. It is insectivorous—that is, it can capture and practically eat small insects that settle on its leaves. Such insects alight on the leaves of the plant in order to find something they delight in, only to discover that they have landed into a death-trap. When I say the Butterwort eats small insects, I do not mean that the plant chews them as with teeth. If you examine the leaves of a living specimen you will see a number of glands on the upper surfaces; these glands secrete a gummy, colourless fluid, which can be drawn out in threads after the manner of many sticky substances. Small insects settling on the leaves are caught in this fluid; their presence causes the plant to increase its secretion, and the fluid turns acid and capable of digesting animal matter. The digestive fluid dissolves everything in the insect that is good to eat, and the leaf absorbs the solution. In this way the plant secures some food elements which in its native situation it would have difficulty in getting in other ways. The indigestible remains of insects are generally to be seen on the leaves of the Butterwort, and I have often seen insects on them which have recently been entrapped.

The Sundew is another insectivorous plant. The commonest species is *Drosera rotundifolia*, the Round-leaved Sundew. This plant frequents wet situations on moorlands, and may be found growing in great numbers amongst bog-moss. The leaves are all radical, and arranged in rosette-like form. The Butterwort leaves are stalkless, but those of the Sundew are borne on short stalks, and are round in shape. I have often thought that they bear some resemblance to a soup-ladle. The leaves are of a reddish colour, and their surfaces are studded with long glands, each one of which secretes a drop of sticky fluid, which looks like a dewdrop on the point of a stout hair. When the leaves are fully developed all the glands point outwards, the numerous little drops of fluid glistening in the sunshine. Perhaps insects mistake the shining globes for dewdrops, and make for the leaves in anticipation of a lovely drink. Whatever the insects actually think about the attractions of the Sundew, there is no doubt about them being caught by the leaves. When they settle in anticipation of a good drink they find themselves glued by the sticky fluid. They struggle to get away, but their struggles make matters worse, for they stimulate the secretion of more fluid. The glands—perhaps they might be called "tentacles" —close in upon the victim, the edges of the leaves turning up and forming a cup, a motion which brings the tentacles together in such a way as to make the insect's escape practically impossible. When the victim is trapped, a digestive fluid is secreted, which, as in the case of the Butterwort, dissolves all the substances of the insect that are "good to eat." The solution is absorbed by the leaf, and the plant is thus nourished.

You can get specimens of the Sundew and feed them at home, just as you would feed lizards, birds, or any other pets. Of course, you must plant them in boxes or pots, allowing them plenty of bog-moss, and keeping them well watered. Feed them with small flies or even tiny pieces of meat. But be careful not to overfeed them; they require very little of such strong food, and they may easily die of indigestion.

I think you will agree with me that the Sundew is a wonderful little plant. Just think of its strange device for securing food; of the clever trap it sets for its intended victims, and the almost cruel manner in which it closes in upon them. To the trapped victim it must be as a cruel, pitiless giant from whose awful clutches escape is impossible. Imagine little children wandering in a forest, hungry and thirsty, finding a huge red leaf, ever so many times bigger than themselves, apparently studded with sparkling globes of water. Thinking that here, indeed, is a crystal, fairy fountain, they attempt to drink. Intead of getting water they find themselves glued to the leaf ; the more they struggle to escape the more glued do they become. Then, horror of horrors ! huge sticky tentacles, more monstrous than those of the Octopus, gradually close in upon them, and they realize that death is inevitable. The death is prolonged and cruel ; a burning fluid is poured upon them, eating like a virulent acid through skin and flesh right into the bones. Surely the Sundew gives us an idea for a fairy tale as wonderful as any that Hans Andersen or Grimm ever imagined !

It is not long since botanists got to know the insectivorous habits of the Butterwort and the Sundew. Had they been known in the days of superstition they would undoubtedly have been made the subjects of some terrible yarns, and possibly the plants would have been looked upon as agents of the infernals. Silly, ignorant men and women would have avoided them as the superstitious avoid graveyards at night.

There are many strange superstitions connected with plants, though happily the spread of knowledge is rapidly killing them. It used to be thought that the Elder was a powerful protection against evil, and that in its presence witches could do no harm. That is why people used to plant Elders either at the entrances to their houses, or in the hedges round their gardens. Even at the present time hedges of Elder are common round old country houses, although nowadays few people know of the ancient superstition. Napier, in his "Folk-Lore," says : "In my boyhood I remember that my brothers, sisters, and myself were warned against breaking a twig or a branch from the Elder hedge which surrounded my grandfather's garden. We were told at the time that it was poisonous ; but we discovered afterwards that there was another reason—viz., that it was unlucky to break off even a small twig from a Bourtree (Elder) bush. In some parts of the Continent this superstitious feeling is so strong that before pruning it, the gardener says : 'Elder, Elder, may I cut thy branches ?' If no response be heard, it is considered that assent has been given, and then, after spitting three times, the pruner begins his cutting." As the Elder has not the faculty of speech, I have no doubt the pruning has always proceeded without further ceremony. It was claimed that if Elder-berries were gathered on St. John's Eve they would protect their possessor from witchcraft, and perhaps bestow magical powers upon him.

Probably the St. John's Worts got their popular names from superstitions regarding them. It was believed that the root of St. John's Wort gathered at sunrise on St. John's Day, and kept in the house, gave luck to the family. If the plants gathered on the same day were hung with crosses over the doors of houses, they would, it was claimed, keep out the devil and all evil spirits.

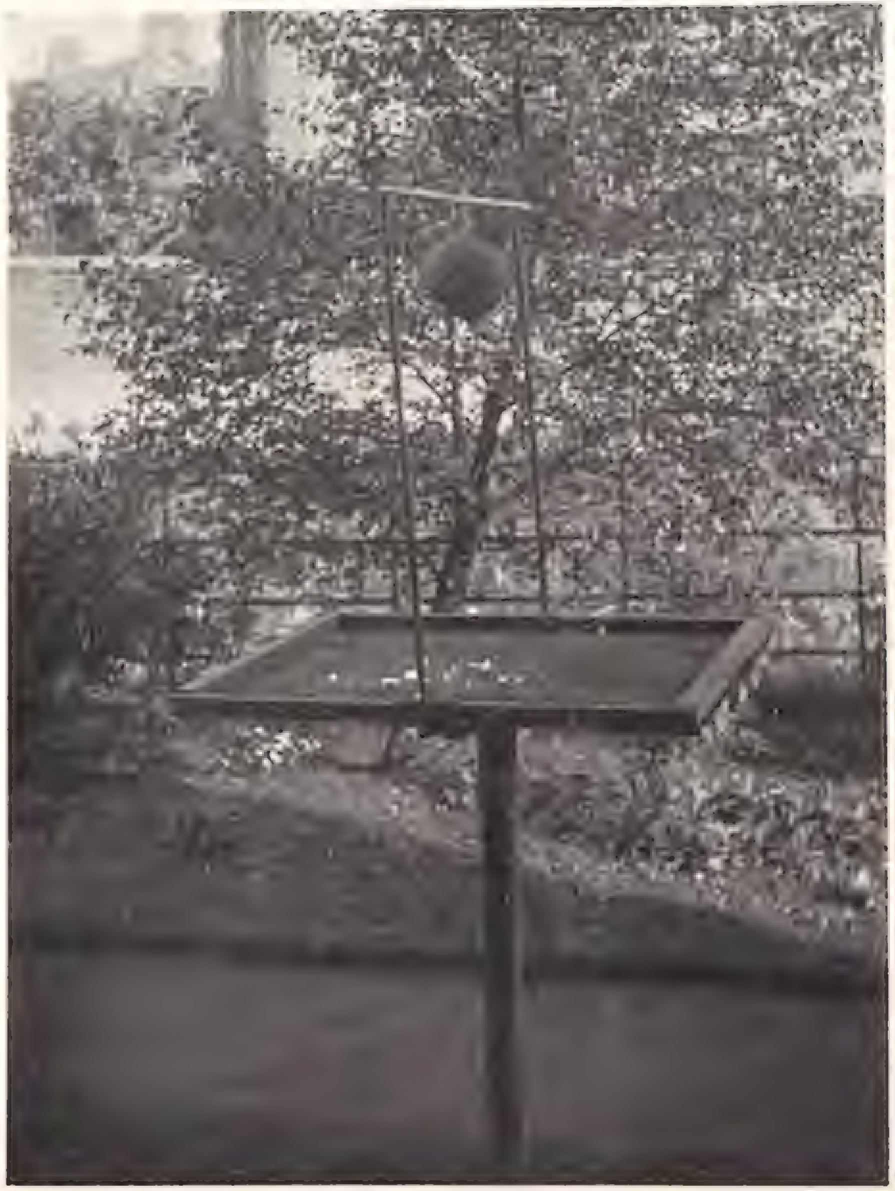
A piece of four-leaved Clover was supposed to possess wonderful protective power exerted for the benefit of its finder, and it also is said to have given its possessor power to see through any schemes or deceits of his enemies.

Well, the evil spirits that we have to deal with to-day are selfishness, greed, indolence, and everything that we know to be bad. Elder-trees around the house, or St. John's Wort hung over its entrance, will not keep these evils away. They are "foes of our own household." We can get rid of them only by "ceasing to do evil and learning to do well." Four-leaved Clover will confer no wisdom upon us; wisdom comes by way of earnest inquiry, faithful application, and duty well done.

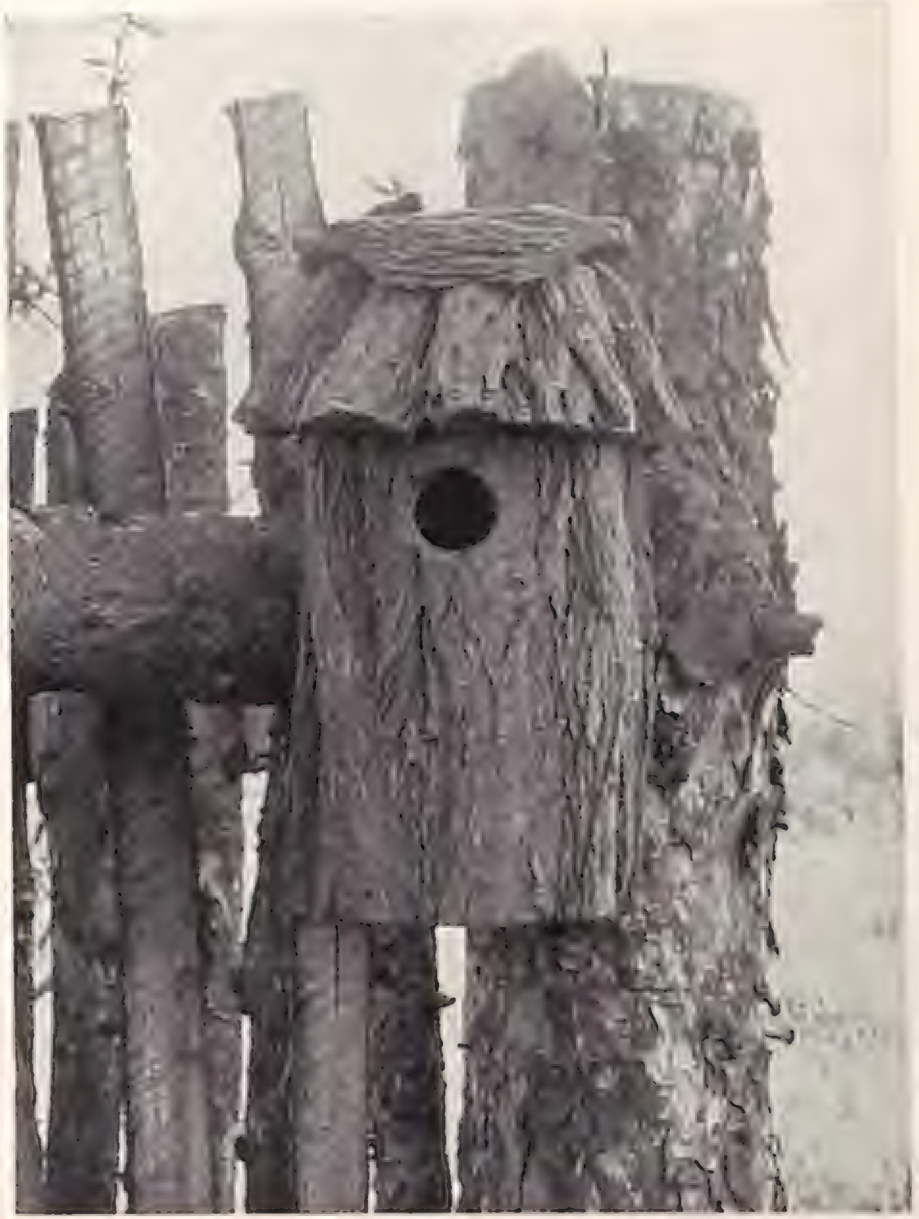
In respect to plants you should learn to associate them with the situations in which they are found. You naturally associate seaweed with the sea, ferns with shady and protected grots, heather with the moorlands. There are plants which flourish best on the seashore, such as the Thrift, or Sea Pink, the Sea Campion, and the Oyster Plant. Others thrive in damp situations, such as the Marsh Ragwort, the Iris, the Ragged Robin, the Water-Mint, and the Spearworts. There are the flowers of the Pastures and Cornfields; the plants of the Roadside, Hedgerow, and Woodlands. If you want to find, say, the Penny Cress (*Thlaspi arvense*) you must not look for it amongst the heather; you are most likely to find it in cultivated fields. And if you desire to secure the sticky burs of the Burdock (*Arctium lappa*) you will look for them on the roadsides or in the hedgerows, not on the tops of mountains.

Plants always adapt themselves to their surroundings, and, of course, they thrive best in the surroundings to which they are adapted. The common Yellow Ragwort (*Senecio Jacobœa*), of dry pastures, and the Marsh Ragwort (*Senecio aquaticus*) are probably descendants from a common stock, but the

PLATE 60

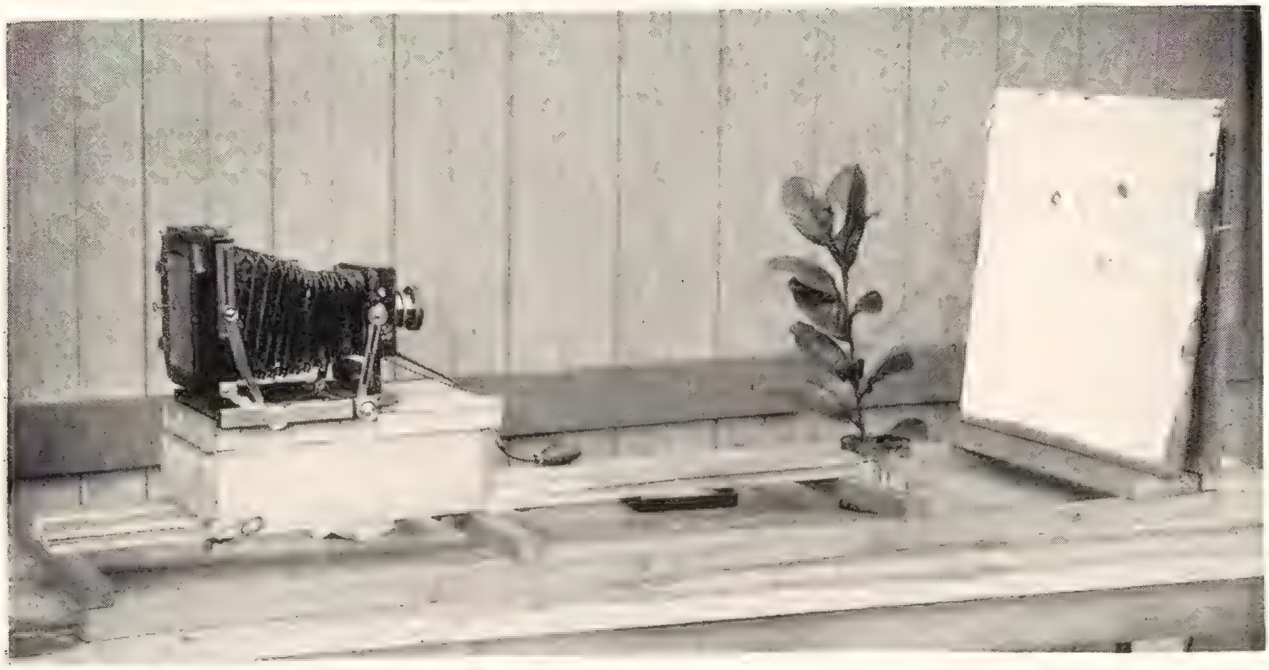


(*a*) Bird Table. *P.* 239.

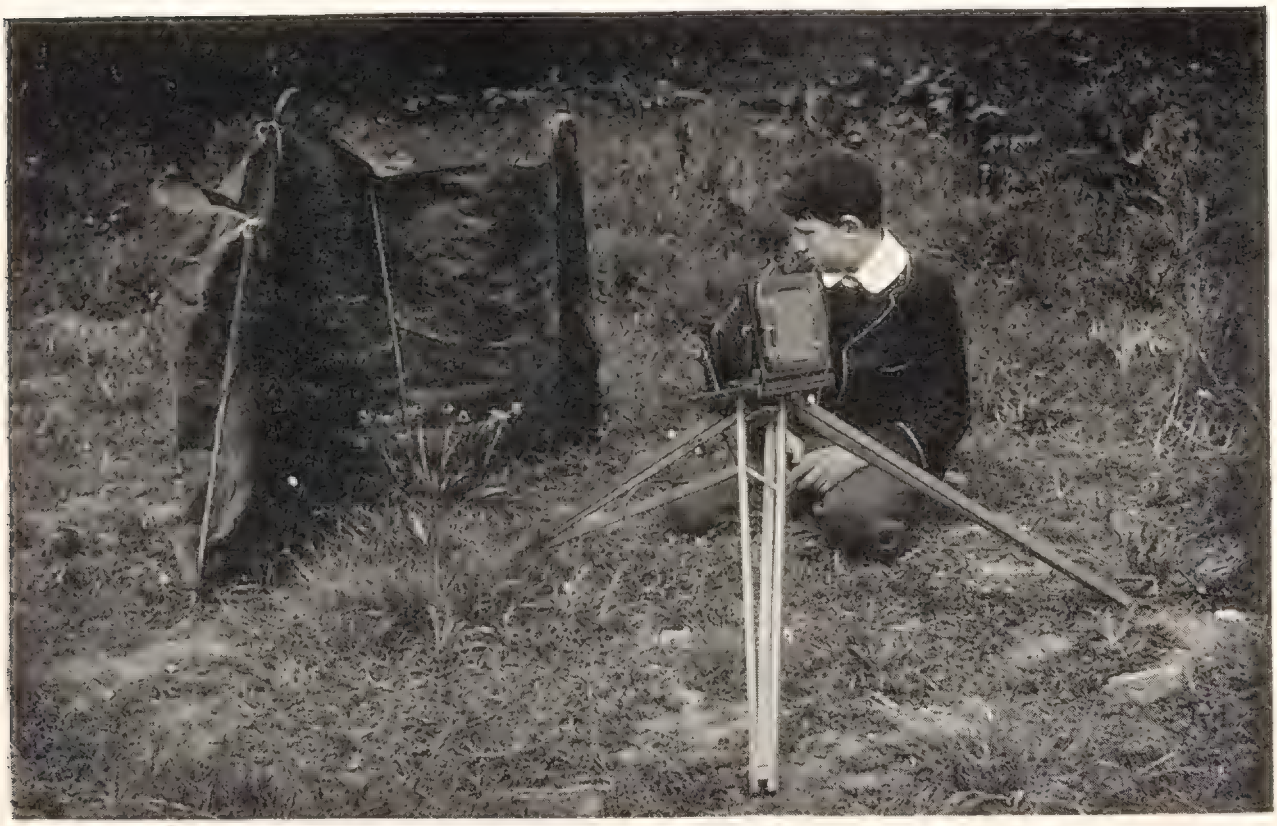


(*b*) Nesting-Box for Tits. *P*, 240.

PLATE 61



(*a*) Apparatus for Photographing Flowers, etc. *P*. 247.



(*b*) Flower Photography under difficulties.

one has adapted itself to pastures, and the other to marshes. The Sundew lives in places where it has little chance of getting anything but water by way of its roots, so it has arranged to catch insects and absorb their juices for food. The Scentless Mayweed (*Matricaria inodora*), when it grows by the sea, becomes quite fleshy in accommodation to its marine situation. I'm not going to give you a lecture on this subject at this hour of the evening, but I mention the matter to set you thinking, and to indicate how much more there is to know about plants than their mere names.

I think I must have been a little tired when we were at the river to-day, or I should certainly have told you that it was a haunt of the Otter. Anglers tell me they often see Otters there, securing fish galore, when they themselves can catch nothing. These animals prefer to fish in the twilight; they are seldom seen near the water during the day. Once they sight a fish they seldom lose it. The animals have jaws that close upon the victim like a vice. When a fish is caught it is usually dragged to the land, and dainty parts of it eaten at leisure. The Otter has a flat, broad head, with whiskers on the muzzle, short rounded ears, and small, black, glistening eyes. Its limbs are short and strong, and its toes are webbed for swimming purposes. The coat underneath is pale grey, shading into brown. The male is bigger than the female, and may weigh a couple of stones or more. The nest is generally made in a hole in a river-bank, and composed of leaves, grass, and other easily gathered herbage. Four or five young are born about the month of June, and a female will fight ferociously in order to protect her bairns.

The Otter has been hunted extensively with the aid of dogs specially trained for the purpose. It can be easily tracked by its strong scent, and it often betrays its presence by giving vent to a shrill call. I suppose the animal is not loved by anglers ; it certainly takes its toll of the fish, but I should be sorry for it to be hunted out of existence.

Bedtime ! All three of us are healthily tired after a busy day with Nature. We ought to sleep soundly. Let us hope that none but happy dreams will be ours ; that we shall be visited by no horrid nightmares, and have no visions of monstrous Sundews holding us in their cruel clutches, and burning out our vitals with acid secretions.

CHAPTER XI

A FEW PRACTICAL HINTS

I PROPOSE now to give my young friends a few hints which I trust will be useful to them in the practical pursuit of Nature-study.

A great amount of entertainment and instruction can be obtained by rearing butterflies and moths from eggs or larvæ. Eggs and caterpillars may be found in the course of your rambles ; they should be secured, taken home, and placed in a "Larvarium," or Breeding-cage, the larvæ to be provided therein with proper food. The eggs will hatch in due course, and the young larvæ will begin to feed straight away. They must, if possible, be fed on the leaves of the species of plants on which the eggs were found, and the collector must always take particular note of the food-stuff with which the eggs are associated. If it is not possible to obtain the exact species of food-plant that the larvæ are accustomed to eat they may be induced to take an allied substitute. Books dealing with the practical side of Entomology usually give lists of substitutes. If you intend to take up the study of practical Entomology seriously, I can recommend no more practical guide than Dr. Knagg's "Lepidopterists' Guide." It can be purchased for one shilling ; it is a perfect mine of information and practical suggestions.

Breeding-cages can be purchased, but I am sure my readers would rather save their pennies by making such as they need for themselves. If you arrive home from a ramble with some larvæ you intend to rear, and have no cage ready for them, you can get a flower-pot, the hole in the bottom of which can be stopped with a cork, or anything that will plug it satisfactorily. The larvæ should be placed with their food in the upright pot, and the mouth of the pot be covered with muslin secured with string. The food-plant will keep fresher if its stem is inserted in a juicy potato. In emergencies of this kind common sense will always suggest a practical way out of a difficulty. Failing a flower-pot a big pickle-jar might serve, or a hat-box covered with muslin.

Probably you will desire a cage that permits more ready observations than can be secured in a flower-pot, jar, or hat-box. In that case you can easily make a cage that will suit your purpose, as well as one that you might pay several shillings for. Plate 62, *b*, represents a small cage I knocked together in an hour one day, when I needed a residence for a caterpillar I had secured, and one that admitted of easy observation, and gave me the opportunity to photograph my captive. This little larvarium is about eight inches wide by nine inches high and five deep. Four uprights of wood are let into a baseboard of one-inch stuff and held firmly at the top by a piece of half-inch stuff. The sides are of perforated zinc ; the back and front are glass. The baseboard being fairly heavy the cage stands firmly, and is not readily overturned. The perforated zinc sides admit plenty of air. The glass at the back is fixed, while the front glass slides in grooves, and can be completely removed when I desire to clean the cage, change the food, and so forth. The food-plant in this cage is placed in a jar of moist sand.

You may, however, make better provision than is made in the cage illustrated. When you have to invent something for Nature-study purposes, make up a list of requirements, and invent accordingly. You have some larvæ. Ask yourself what larvæ require. They need food and air; then arrange for a proper supply of both. You wish to keep the food fresh; then supply it with moisture. The larvæ will change into pupæ. Some will make cocoons in corners of the cage; others will want to bury themselves. For the latter you must provide sand, loam, cocoanut fibre, moss—whatever you deem most suitable. Then you must so construct your cage that your captives cannot escape. In the cage I have described there is no sand or moss provided for the "change." Then it might be improved by having two chambers in the bottom, one containing sand, fibre, or moss for the "change," and another to hold vessels of water or moist earth for the benefit of the food-plants. This chamber should be covered with a lid in which a few small holes are made to admit the stalks of the plants.

When the perfect insects emerge from the pupa state you may allow the females to leave you some eggs from which to rear more specimens, or, having had the satisfaction of watching their developments, you may set both males and females free to populate the earth with their kind. Perhaps you will wish to preserve some specimens for your museum collection ; in that case they will have to be mercifully killed and properly set. To kill them they may be placed in a closed jar containing bruised laurel-leaves ; or, better, each specimen can be secured in a suitable pill-box punctured with little holes. The pill-boxes containing the insects can then be placed in a jar into which a piece of sponge or blotting-paper saturated with strong solution of ammonia has been inserted. The jar, of course, will have to be closed at the mouth, so that the fumes do not escape. The insects should be left for some hours in the jar, and before they are set they should have at least half an hour in fresh air, otherwise the ammonia that clings to them may corrode the pins.

For setting the insects suitable setting-boards are necessary, and these can be made at home. A flat piece of soft wood, say a foot long and of a width suited to the size of the insects to be set, is covered with strips of sheet cork, so arranged as to provide a groove along the middle of the board from end to end. This groove is to admit the bodies of the insects. The whole is covered with white paper. An entomological pin is inserted into the thorax of the specimen to be set, and by this its body is fastened into the groove of the setting-board. The wings are stretched into a suitable position, and held there by wedge-shaped battens of thin cardboard attached to pins. After being held thus on the setting-board for a few days, the insects will by stiff and ready for their places in the cabinet. Thee should be arranged in proper order, and the cases containing them should be as air-tight as possible. To keep mites from attacking the specimens a small piece of camphor should be placed and secured in a corner of each case. Don't admit any more light to your specimens than is really necessary, and don't make up cases to be hung in full daylight on a wall. Specimens soon deteriorate when submitted to the continued action of strong light. Always use proper entomological pins, as ordinary pins soon corrode and ruin the specimens which are held by them. The right sort of pins can be had from dealers, whose advertisements may be seen in various journals devoted to Nature-study.

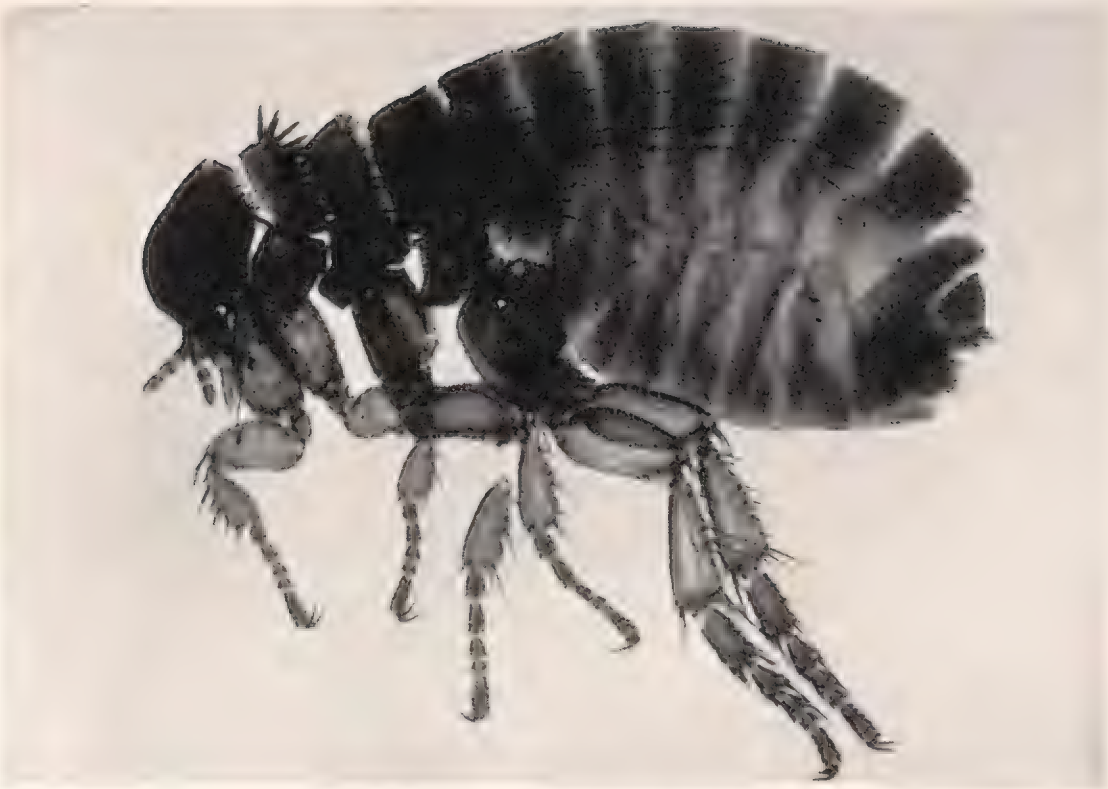
There are some foreign insects, such as the Praying Mantis and the Stick Insects, which make very interesting pets. The eggs may be had from the dealers and hatched out at home, the insects being accommodated in suitable cages.

For the identification of Butterflies and Moths, and also for guidance in their classification and arrangement, you will find Gordon's " Our Common Butterflies and Moths " an excellent volume. It contains a thousand coloured illustrations, and is not expensive.

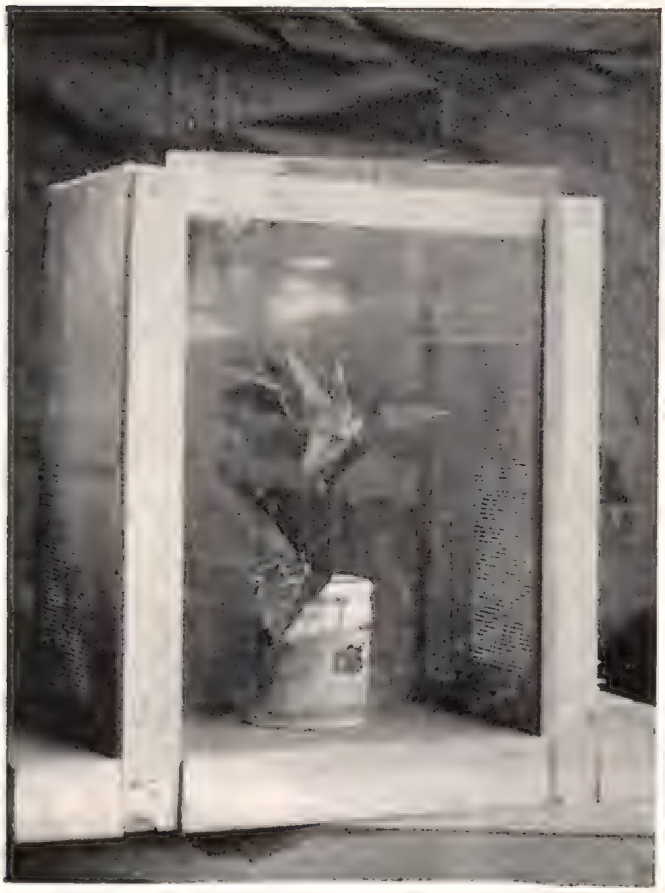
In winter-time hunger makes birds bold. As you know, they may be attracted to close quarters by the judicious scattering of food. You should take every opportunity of observing them carefully when hunger brings them so near to your homes. If possible a bird-table should be fixed near a window from which the visiting birds can be watched. Plate 60, *a*, gives you a representation of a bird-table which I have had in use for some years. It is a table made of light boards ; it measures about two feet square. It is fixed on to the end of a pole driven into the ground, and is situated so that I can not only watch the visiting birds, but also photograph them. Some bird-tables have little railings of wires around them. These wires keep Sparrows and any undesirables off the board, but they are not objected to by Tits. Personally I welcome all comers ; but for the special benefit of the Tits I have the little arrangement of bamboo-canes holding a pendant cocoanut, as shown in the illustration. The Tits enjoy the cocoanut, while Robins, Thrushes, Blackbirds, Hedge Sparrows, and other visitors hold high revel on the seeds and crumbs scattered on the board below. During snow and frost I give my visitors an allowance of sand and water, for which they seem grateful. If you have never tried a bird-table you should do so without fail. The birds will provide you with an entertainment as amusing as any pantomime.

I have already mentioned that I take it as a great compliment if birds nest in my garden. I do all I can to induce them to do so, and those of you who have gardens should certainly follow my example. The thing is to provide them with suitable nesting sites. This is done by making nesting-boxes, and placing them where the birds can use them without fear of being molested by their natural enemies. There are no more interesting and amusing tenants of a nesting-box than a pair of Tits. They build a lovely nest, lay dainty wee eggs, and bring up a charming family. Plate 60, *b*, is an illustration of a

PLATE 62



(*a*) Photo-micrograph of Dog-Flea (female).



(*b*) Larvarium. *P.* 236.

(*c*) Microscope and Pocket Lens.

nesting-box made specially for the benefit of Tits. You will see that it is covered with bark, and is placed on a bark-covered fence, which matches it very well. It has a small hole for entrance and exit, and a removable lid to enable observation of what is going on inside. This box secured first prize in a competition promoted by Mr. W. Percival Westell, the secretary and founder of the Young Naturalists' League. Of course, you may make boxes that are easier to construct. The points you have to keep in view are suitable size for the birds you hope to attract, a sloping lid to throw off water, and an entrance hole, which for Tits should not be much bigger than a penny. A nesting-box for small birds need not be more than six or seven inches cube. Tits require no perch outside their box. Sparrows like perches outside, and require the holes to be rather larger. Starlings need an even bigger hole, and more room in the box. Robins will build in all sorts of curious places ; in an old kettle or a cast-off hat. I have seen a nest in the pocket of an old mackintosh hanging dust-laden in a barn !

Don't paint the outsides of your nesting-boxes with gay colours. Let them appear old, dirty, and just as if they grew where they are placed. It is not a bad plan to give them a coat of dull paint, and, while yet wet, rub them over with earth.

For the study of pond-life you will need to rig up an aquarium of some kind. For lack of anything better, you can work with glass jars, or a cheap gold-fish bowl. But round vessels give a distorted view of their contents. With the exercise of a little ingenuity you should be able to make a square glass tank, with perhaps a slate bottom, and metal uprights, to hold the glass sides and ends in position. The glass can be cemented in grooves of the uprights with a mixture of red and white lead. In stocking your aquarium, some preparation must be made for the tenants. Pebbles and sand should cover the bottom to the depth of about an inch ; pond-weeds should be planted therein, and the tank filled with water. Some duckweed will do good on the surface of the water, and water-snails will keep the inner surface of the glass from being covered with scum. The vegetation in the aquarium keeps the water oxygenated, and if you arrange matters skilfully, there will be no need to change the water ; but the quantity lost by evaporation must be made up from time to time. After your aquarium has been occupied by plants for a couple of weeks, you can introduce your live-stock, such as Newts, Sticklebacks, Beetles, Water Fleas, Cyclops, and so forth.

For microscopic purposes it is advisable to keep special specimens in separate jars, otherwise they may disappear into the interiors of voracious newts or sticklebacks. Newts make attractive pets ; they become quite tame, and may be induced to take small worms hanging from the fingers. Pond-life is a study in itself, and an extensive literature is devoted to it. For beginners two small books in the "Young Collector Series" are useful ; one is "Pond-Life (Insects)," by E. A. Butler, and the other "Pond-Life (Algæ, Diatoms, etc.)," by T. S. Smithson. They are sold at one shilling each.

Now a few words about Nature photography.

I do not see why a lad of ordinary intelligence, with knowledge of the use of tools, should not make a Camera for himself. The Rev. S. N. Sedgwick, M.A., in his " Young Peoples' Nature-Study Book," gives directions for the construction of a camera which need not cost its maker more than a few shillings. It is really a most ingenious invention, and excellent results can be obtained by its use. The absolutely necessary parts of a camera are few—a light-tight box, a lens, a shutter, a focussing-screen, and a dark-slide or plate-holder. Bearing these in mind, surely a smart boy can make a camera, and add various contrivances which will make it easier to use.

In purchasing a camera for Nature-work, bear in mind that a cheap magazine camera will not suit. You would find it an excellent instrument for wasting plates. I take it for granted that expensive Reflex cameras are out of the question, so I advise you to buy as good a stand camera as you can afford. Nearly all the photographs which are reproduced in this book were taken with a two-guinea quarter-plate camera, supplied by Messrs. W. Butcher and Sons, Ltd. It is furnished with a cheap rapid rectilinear lens, and has what is a *sine qua non* for the naturalist—double extension bellows. I believe Messrs. Butcher supply a camera which will do good work for a guinea. Their " Klimax " camera, costing over £4, quarter-plate, is a very useful instrument. Don't waste money on a camera that will fail to give satisfaction ; save up your money until you can get a good one. I see no reason why you should not make your camera pay for itself and the material you use. Once you become proficient in the art of taking pictures, you should be able to find a market for them.

In Nature-work you have to place your camera in all sorts of curious positions to suit your subjects, and you have to devise ways and means of getting pictures that are not exactly straightforward work. The more movements your camera is capable of, the better will you be able to get at your subjects. A stand with a tilting-board is extremely useful ; I mean a simple apparatus whereby the camera can be tilted forward at various angles, and even be made to point straight down to the ground. A tilting-board can be easily made by an amateur. I shall not go into details of its construction ; I tell you what is wanted, and leave you to construct a contrivance suitable for the purpose. Sometimes you will need to lengthen your stand by tying sticks to it (see p. 156) ; at others, one or two legs may have to be shortened ; and, again, occasions arise when it is best to dispense with the legs altogether. When you find a difficult subject, examine it from all points of view, think how the difficulties are to be met, then set to and meet them.

The photography of birds and wild animals is exceedingly trying to one's patience, and sorely taxes one's ingenuity. More often than not the photographer has to contrive a hiding-place for himself and camera in a place near a nest or a particular haunt. A tripod of sticks covered with dull green canvas, and festooned with branches of trees, is a good hiding-place. Of course, there must be a means of entrance and exit, also a small hole for the lens of the camera, and facilities for observation. The camera is focussed on, say, a nest, the dark slide is placed in position, and when the bird is in a suitable position, an exposure is made. Generally the hiding-place has to be left in position for a day or two, until the birds get used to its presence. Patience and perseverance, with common sense and ingenuity, are very necessary virtues for the Nature photographer to possess.

As to the general manipulation of a camera, the development of plates, and the making of prints, I shall say little. You can get much free information from makers of cameras and materials, and all the guidance you are likely to require in a handbook costing only a few pence. The amateur learns by his blunders.

In Nature pictures you require detail, and to secure this you have to "stop down" your lens to a fairly small aperture. The smaller the aperture, the longer the exposure. Snapshots are sometimes necessary, but avoid them where possible. Stop down your lens, and give a reasonable full exposure. I often stop down to aperture f/44, and give anything from twenty seconds to a minute's exposure. Such, however, can be done only with still subjects.

For developing I use Rodinal. It is, in my opinion, the best developer going, but it must be allowed full time in order to secure sufficient density in the negative. I watch for the appearance of the image, counting the number of seconds between the time of pouring the developer over the plate and the "coming up" of the "high lights." I multiply that number by forty, and the time thus arrived at is that which I allow for complete development, when Rodinal is used. Thus, if it takes twenty seconds for the image to make its first appearance, that number multiplied by forty gives eight hundred seconds, or a little over thirteen minutes. I let my plate, then, lie in the developer for thirteen minutes, then wash and fix it, and am sure of a good result, if the exposure has been right and there has been no mishap of any kind. Always cover the dish while the plate is lying in the developer. More plates are failures through under exposure and under development than from any other causes.

Orthochromatic plates should always be used in Nature photography ; they give better colour values than ordinary plates. I generally use the Imperial Company's Non-Filter Ortho. plates ; I find them excellent, but they are liable to be "fogged" if the dark-room light is too brilliant. They should be handled in a very dull red light, and be always covered while development is going on.

The printing process is a matter of personal taste and convenience. P.O.P. gives the best results, in my own humble opinion. But the gaslight process is very convenient and speedy. I have found some Self-Toning papers exceedingly useful.

Nothing pleases me more than a good lantern-slide made from a "Nature" negative. When such a slide is exhibited through an optical lantern, details appear that are not seen on flat-paper prints. You can make lantern-slides quite easily, and you will find them exceedingly useful if you want to illustrate a little Nature-talk given for the benefit of your friends. Lots of cheap booklets giving all necessary instructions for the making, mounting, and exhibiting of slides are obtainable.

Many subjects are best photographed under "control." Snakes, lizards, frogs, toads, etc., can be secured in glazed cages having suitable backgrounds. Butterflies and moths are generally photographed in captivity in their breeding-cages. Newts and fish may be put in narrow glass tanks, furnished with pebbles and weeds. Such tanks need not ordinarily be more than an inch and a half from front to back; they must have clear glass front and back, and a simple apparatus enabling a continuous supply and exit of water will improve matters. A suitable background behind the tank is necessary.

In Plate 61, *a*, you have a picture of apparatus I use for photographing flowers, etc., by the control method. The camera is set on a sliding trolley, which is secured in the necessary position with a butterfly-bolt. There is an easel on which a suitably tinted background is fixed. The apparatus is put on a table near a window admitting light from the north. A white paper reflector is placed in such a position that it reflects light on to the specimen, and thus even lighting is obtained. I usually stop the lens down to aperture f/32, and in an ordinary light give from thirty to forty seconds' exposure. The same apparatus is used for copying prints and illustrations, and also in photo-micrography; it was made at home, and has become almost indispensable.

A good Field-Glass is of immense service to the naturalist, especially for the observation of birds.

The best kind that can be had for this purpose is a Prism Binocular, but such an instrument is rather expensive. There are, however, good glasses which are to be had secondhand, or even new, for a moderate sum. I often use a glass which I purchased for half a guinea ; it enables me to observe the "points" of birds with great accuracy. The same glass serves for occasional observation of insects, and it has often enabled me to identify plants which I cannot reach without great difficulty, and which, at a distance, are not clear to the naked eye.

No naturalist moves about without a Pocket-Magnifier ; it is useful in a hundred ways, and need not be expensive. One can be got as low in price as sixpence, and a shilling glass will do very good work. Of course, higher prices can be paid. For some time I have carried a pocket-magnifier having three lenses, which can be used one, two, or all three at a time, according to the magnification required. I think it cost me three and sixpence. The best lenses are the Platyscopic or Aplanatic ; they give splendid definition, good magnification, and have ample working distance, but they are rather expensive.

A Microscope is not absolutely necessary for ordinary observation, but it is a most delightful instrument to possess. One can be a good naturalist without its assistance, but it unquestionably opens up fields of inquiry that cannot be tackled without it. A hand-magnifier can be rigged up on a stand, and made to render good service in the observation and dissection of small objects. Thus arranged, the hands are left free for work. The stand might consist of a block of wood, or metal, for both foot and table for the object, and an upright wire inserted into the block, as a holder for the lens, which should be made to slip up and down on the upright, so that focussing can be effected.

When I was about twelve years old, I was in desperation for a microscope, and, alas ! as so often happens with youngsters, I had no money. Necessity was the mother of invention. I begged some small lenses which my father had by him, and fitted them into cardboard tubes, which I made myself. I fixed up a couple of objectives and an eyepiece, made a tube for their reception, contrived a stand out of some odd bits of wood, used a piece of looking glass for a reflector, and supplied myself with some slips of glass for my objects. Well, that was, in truth, a rough-and-ready microscope, but I used it until I could get a better one. I mention this personal incident to show that "where there's a will there's a way." A determined youngster will not allow poverty to stand in the way of his studies. Determination and brains are the best kind of capital of which I have any knowledge.

Perhaps you will permit me to indulge myself in another personal note. The microscope which I obtained in the second instance was not got for the asking. I think it cost me about £3, and it would have taken long, weary months for me to make up that sum out of my scraps of pocket-money. I was determined to have my instrument as soon as I could possibly get it. How was I to raise the money ? I soon hit upon the solution of my problem—I would work for it. My father was going to have some fences painted. I offered to do the work—for a consideration. Then I made up little cases of insects and sold them. I turned fretwork to account, made a little plunder from postage-stamps, and onion-nets, which an old village worthy had taught me to make. In quite a short time I had realized a little over £2. One good day my father, who had evidently watched my proceedings with interest, and knew what I was after, asked me how I was getting on. I told him, and he was so pleased with my determination that he made up the required amount. As one might say, I secured my instrument in the "twinkling of an eye."

I strongly advise the reader who is determined to possess a microscope not to waste good money on any sort of instrument. A lot of the cheap microscopes that are displayed in shop windows are made to sell, not to do good work. An effective instrument cannot be made for the price at which those cheap ones are sold. It may be thought that a cheap instrument will do all that is required of it; it can certainly give some magnification, but as likely as not it will present a distorted image to the eye, and make the object look as if it were fringed with all the colours of the rainbow. If one of these microscopes be purchased, it will soon be discarded, and when the time comes for the purchase of a satisfactory instrument, you will wish you had not spent good money on one that is practically useless.

Now, a microscope capable of doing all the work that an ordinary student requires of it need not be an elaborate and expensive instrument. Buy at first a good stand, furnished, perhaps, with one eyepiece and one objective; add other eyepieces, objectives, and accessories as you need them or can afford them. High magnification is sometimes necessary, but I can assure you that most Nature-work is done with low powers.

I have just been doing a little work with two microscopes made by Messrs. R. and J. Beck, Ltd., 68, Cornhill, London. One of them is called the "Star," and I am sure no better or cheaper instrument could be made for the use of beginners; indeed, I know a number of advanced workers who make use of it, and speak highly in its praise. The cost of a "Star" stand with one eyepiece and one 1-inch object-glass is about £3; with an extra eyepiece and a ¼-inch objective in addition the cost is £4 6s. The other microscope is the "London," a real beauty, finished with the greatest nicety, and delightful to handle. But it is more costly than the "Star." The stand alone, in a mahogany case, costs £3 5s. 6d.; with the addition of an eyepiece and two object-glasses, the bill amounts to a little over £5. This outfit gives a range of magnification from 50 to 270 diameters.

I mention these excellent microscopes to give you an idea as to what price you must pay for an instrument by a reliable maker. There are a number of firms whose work can be depended upon; I have cited Messrs. Beck because I have worked with several of their instruments, and know their points.

When you possess both camera and microscope, you will be able to use the two in conjunction, and secure photographs of objects as they appear under the microscope. Such pictures are called "photo-micrographs," and the process of taking them is designated "photo-micrography." The process is not so difficult as it may seem to some of you. I took photo-micrographs when I was thirteen years of age. The lens of the camera is removed, the microscope placed in a horizontal position, with the end of the tube containing the eyepiece inserted into the hole in the front of the camera. Light is focussed upon the object, the connection between camera and microscope being made light-tight. The image is projected on to the camera screen and focussed. Then a dark slide is inserted and an exposure made. Exposures vary according to intensity of light, density of object, and the magnification ; they are generally long. There are several reproductions of photo-micrographs among the illustrations of this book ; all the pictures were obtained by the simple method I have just outlined, the apparatus being conveniently arranged on the board I use for flower photography and copying (p. 247). My exposures varied from thirty to sixty seconds, electric light being used.

Finally, let me insist upon the necessity of keeping the fullest possible Nature records, especially of observations made in your own localities. It seems trivial to note a lark singing on April 1, or the appearance of a Spotted Orchis in June, but even the most trifling observations have their value. If you hear birds or see plants in advance of their usual seasons, you may be sure that such phenomena have their special causes. So full should your records be that in any subsequent season you may look back upon your notes of any particular year, and make comparisons. In course of time you will be able to compile a Nature Calendar from your notes ; you can show what birds, insects, flowers, etc., are likely to be in evidence month by month. Mr. Percival Westell has published, through the Educational Company of Ireland, a Nature Diary, in which columns are arranged for weather, temperature, birds, insects, trees and hedges, wild flowers, pond-life, farm and crops, garden and general notes. Blank forms for monthly weather-charts are also provided. This is a very useful Diary, and only costs sixpence. Of course, anyone can rule a blank notebook and arrange a diary on systematic lines, but Mr. Westell's Diary makes provision for all necessary records, and costs little more than a blank book.

Now I bid adieux to my readers. My space is already exceeded, yet I feel there is so much to be said that I have not said. Perhaps I may be encouraged to say just a little more in another volume. I hope my young friends will become thorough naturalists, and find in the reverent study of Nature the solace and delight that I have discovered. As Emerson wrote :

> "All my hurts
> My garden spade can heal. A woodland walk,
> A quest of river-grapes, a mocking thrush,
> A wild-rose or rock-loving columbine,
> Salve my worst wounds."

GLOSSARY

Acotyledon : Plants having no distinct cotyledons. See **Cotyledon.**
Acuminate : Gradually tapering to a point.
Acute : Sharp, pointed.
Amber : Fossil resin.
Ammonites : Extinct molluscs, so called because their fossil shells are likened to the ram-like horns of the statue of Jupiter Ammon.
Amphibians : Animals able to exist either on land or in water.
Ancyloceras : An extinct cephalopod like an unrolled ammonite.
Antennæ : The horns or " feelers " of insects, crustaceans, etc.
Anthers : The pollen sacs or vessels of stamens.
Anthracite : A variety of coal containing a high percentage of carbon, and almost smokeless.
Aquarium : A tank or vessel made to hold and keep alive water plants and animals.
Arachnida : Greek, *arachnē,* a spider ; a sub-class of the Arthropoda, including spiders, mites, and scorpions.
Araucarias : Evergreen trees allied to the pines, and commonly known as " monkey puzzles." Named after a province in the South of Chili.
Archæan : In geology, the earliest deposits.
Archæopteryx : The earliest known kind of birds.
Arthropoda : A great subdivision of the animal kingdom, including such jointed creatures as insects, spiders, mites, centipedes, millipedes, crabs, lobsters, etc.
Articulated : In zoology, possessed of distinct joints, jointed.
Ascending : In botany, curved upwards into an upright position.
Atlantosaurus : An extinct monster.
Awn : A pointed bristle.
Barren : Bearing no fruit.
Belemnites : Fossil remains of internal shells, " pens " or " guards " of cuttle-fish.
Biped : A two-footed animal.

Bipinnate : Twice-pinnate leaves; pinnate leaflets again pinnate.

Botany : The science of plants. Greek, *botanē*, herb.

Bracts : Small leaves between ordinary leaves and flowers.

Breccia : A sedimentary rock, formed of angular and unworn fragments cemented together.

Brontosaurus : An extinct monster.

Bulb : A bud composed of fleshy scales, usually underground.

Cainozoic : Rocks of the third great geological era, containing fossil remains of numerous recent life-forms.

Calamites : Gigantic fossil plants allied to existing horse-tail plants.

Calcite : A mineral composed of native carbonate of lime (calcium).

Calycifloræ : Dicotyledonous plants, having stamens inserted in the calyx or near to its base.

Calyx : The outermost covering or whorl of a flower.

Cambrian : The oldest system of the Palæozoic rocks. Name derived from *Cambria* (Wales), where the rocks are typical.

Carapace : The protective shell of a crab, tortoise, etc.

Carbonaceous : Composed mainly of carbon.

Carboniferous : Rocks of the Palæozoic Era, including the Coal Measures.

Carnivorous : Flesh-eating.

Carpels : Divisions of the ovaries of plants.

Cataclysm : A deluge.

Cephalopods : The highest order of molluscs, including the cuttle-fish.

Ceratodus : The Australian mud-fish.

Chert : A species of flint.

Chlorophyl : The green colouring matter of plants.

Chrysalis : A stage in the development of an insect,intermediate between the larva and perfect insect.

Ciliate : Possessing cilia or hair-like lashes.

Claystone : Clay hardened into stone.

Cocoon : A sheath or cell spun by larvæ in which they turn into chrysalides.

Cœlenterata : A group of lowly animals which have no internal cavity distinct from a digestive tube.

Compound : In botany, formed of many similar parts.

Conferva : A term applied to a group of lowly water plants known as *Algœ*.

Conglomerate : A rock composed of rounded pebbles set in a mass of cementing material.

Connate : Joined at the base.

Cordata : Vertebrate animals possessing nerve cords.

Cordate : Heart-shaped.

Corm : A solid, fleshy, bulb-like underground stem, not composed of a series of scales.

Corolla : A whorl of petals between the calyx and stamens, usually coloured.

Corollifloræ : Dicotyledonous plants whose petals are united and bear the stamens.

Cotyledons : Seed-lobes.

Crenate : Having rounded teeth on the margin.

Cretaceous : The highest system of the Mesozoic rocks.

Crinoids : Sea-lilies.

Crustacea : An order of Arthropod animals, including crabs, lobsters, water-fleas, etc.

Cuneate : Wedge-shaped.

Cycads : Plants allied to the pines, but resembling palms and tree-ferns.

Cystideans : Animals allied to the sea-lilies. They flourished in Cambrian and Silurian times.

Deinocerata : A group of extinct mammals.

Deinosaurs : An extinct order of reptiles.

Deinotherium : A huge extinct animal which possessed two large tusks in the lower jaw.

Dentate : Having marginal teeth, triangular and pointed.

Devonian : Term applied to a system of rocks of Palæozoic age.

Diatoms : One-celled Algæ possessing flinty shells.

Dicotyledons : Plants having seeds with two lobes.

Dip : In geology, the angle at which strata incline.

Dipterus : A fish of Old Red Sandstone age.

Dyke : A mass of igneous rock intruded into a fissure of other rocks and often standing out like a wall.

Echinodermata : A class of animals, like sea-urchins and star-fish, having skins strengthened by spiny plates or hard granules.

Elliptical : In botany, oval, but acutely pointed at each end.

Entire : In botany, having an unbroken margin.

Entomology : The science which relates to insects.

Envelope : In botany, the outer whorl or whorls of the flower, the perianth.

Eocene : The lowest system of the Cainozoic Era.

Eozoic : The oldest of the four geological eras.

Erect : Rising immediately to an upright position.

Fault : A break in the continuity of beds of rock.

Felspars : A family of minerals entering largely into the formation of igneous rocks.

Fertile : Fruit-bearing.

Filament : In botany, the stalk of the stamen bearing the anther.

Flint : An impure form of silica.

Foraminifera : Tiny one-celled animals possessing perforated shells of carbonate of lime.

Fungi : A group of lowly plants, including mushrooms, moulds, and bacteria.
Galls : Growths on plants caused by insects or fungi.
Ganoids : The earliest known type of fishes, having defensive armour.
Gasteropoda : A group of molluscs which creep on a broad expansion of the body which serves as a foot (snails).
Geology : The science of the earth, its formation, development, and history.
Glumes : Scales or bracts of grasses and sedges.
Glumaceæ : A sub-class of plants, including the grasses and sedges.
Gneiss : A metamorphic rock.
Granite : A crystalline Plutonic rock.
Graphite : A black, opaque mineral, composed of nearly pure carbon.
Graptolites : A group of Palæozoic organisms.
Grit : A sandstone, composed of coarse, angular quartz fragments.
Gymnosperms : Plants bearing naked ovules, without styles or stigmas.
Gypsum : A mineral composed of hydrous sulphate of calcium.
Hamites : A variety of fossil cephalopods.
Hastate : The shape of a spear-head.
Herbarium : A collection of preserved plants.
Hibernate : To pass the winter in a state of sleep or torpor.
Horizon : In geology, a bed or number of beds of strata in which typical fossils occur.
Hybrid : A mule or mongrel, a plant produced from two different species.
Hypo. : Hyposulphite of soda, used in photography.
Ichthyosaurs : A group of extinct fish-lizards.
Igneous : Produced by the action of heat.
Iguanadon : An extinct reptile.
Imparipinnate : Leaflets of pinnate leaves arranged in pairs with an odd terminal leaflet.
Inflorescence : Flower arrangement.
Insectivorous : Feeding on insects.
Invertebrate : Without a backbone or vertebral column.
Involucre : Bracts arranged in a whorl at the base of a single flower, an umbel or a head of flowers.
Jurassic : The second system of Mesozoic rocks.
Labellum : The lower lip of the flowers of orchids.
Labyrinthodonts : A group of extinct amphibians.
Lamellibranchia : Bivalve molluscs, like the cockle and oyster.
Lamina : The blade of a leaf, petal, etc.
Lanceolate : Lance-shaped.

Larva : The caterpillar stage of an insect.

Larvarium : A feeding-cage for larvæ.

Legume : A pod, like that of the pea.

Lepidodendron : A fossil plant, said to have been a gigantic club-moss.

Lepidopterist : A person who collects and studies scale-winged insects (butterflies and moths).

Lias : Jurassic strata extending across England from Lyme Regis to Whitby.

Lichens : Cellular flowerless plants.

Lignite : Brown coal.

Limonite : Brown or " bog " iron ore.

Linear : In botany, long, narrow, with parallel sides.

Liverworts : Lowly plants nearly related to mosses.

Loam : A soil formed of sand, clay, vegetable and animal matter.

Lycopods : Plants of the quillwort and club-moss type.

Mammals : Animals that suckle their young.

Mammoth : An extinct shaggy-coated elephant.

Mandibles : Appendages used for tearing up food in preparation for eating, as in cray-fish, bees, etc.

Marl : A mixture of clay and lime.

Mastodon : An extinct kind of elephant.

Megalosaurus : A huge extinct carnivorous reptile.

Megatherium : An extinct sloth of large size.

Mesozoic : The middle age of life. The third great geological era.

Metamorphic : Term applied to rocks whose materials are re-arranged by pressure, etc.

Mica : A glistening mineral which can be readily split into thin, shining plates.

Miocene : The third and middle period of the Cainozoic Era.

Mollusca : Soft-bodied animals, usually possessing shells, including the shell-fish.

Monochlamydeæ : A sub-class of plants whose flowers have but one floral envelope.

Monocotyledons : A class of plants whose seeds have but one cotyledon.

Mucronate : Tipped at the apex with a short point.

Mylodon : An extinct kind of sloth.

Myriapoda : A class of segmented animals, including the centipedes and millipedes.

Nectary : An organ in flowers which secretes honey.

Nodes : In botany, the points on stems where leaves spring from.

Obcordate : Inversely heart-shaped.

Oblong : In botany, long oval, equally broad at each end.

Obovate : Inversely egg-shaped.

Obtuse : Blunt, not pointed.

Ochrea : A membranous stipule which surrounds the stem.

Odontophore : The " tongue " of certain molluscs.

Oldhamia : A Cambrian fossil.

Oligocene : The second of the five periods of the Cainozoic Era.

Orbicular : Nearly round and flat.

Ordovician : The second of the six periods of the Palæozoic Era.

Ornithology : The study of birds.

Outcrop : The edge of tilted strata as it appears on the surface.

Ovary : The young seed-vessel.

Ovate : Egg-shaped.

Oviparous : Bringing forth eggs.

Ovules : Immature seeds.

Palæontology : The science of ancient life, the study of fossils.

Palæozoic : The second of the four great geological eras.

Palmate : Having lobes spreading out from a centre, like the fingers of the hand.

Pappus : The hairy or downy crests of the fruits of composite plants. Example, dandelion " clock."

Parasite : A plant or animal living at the expense of another plant or animal.

Pariasaurus : An extinct reptile.

Paripinnate : A leaf with an equal number of distinct leaflets on either side of the stalk, all leaflets being opposite.

Pedicels : Branches of a common flower-stalk or peduncle, each branch bearing a flower.

Peltate : A leaf which has its stalk attached to its surface, not to its margin or base.

Pendulous : hanging, attached in a hanging fashion.

Perfoliate : When the stem seems to pass right through the blade of the leaf.

Perianth : The outer envelope of a flower in which calyx or corolla cannot be distinguished.

Pericarp : The outside or rind of fruits.

Permian : The last of the six periods of the great Palæozoic Era.

Petals : The usually coloured leaves of the corolla.

Petiole : The leaf-stalk.

Pinnatifid : Leaf cut deeply into segments reaching nearly to the midrib.

Pistil : The female organ of a flower. The pistil includes the ovary, style, and stigma.

Peat : Compressed and altered vegetation, which can be used for fuel.

Petaloidæ : A sub-class of monocotyledonous plants whose flowers have petals.

Photo-micrography : The process of taking photographs of microscopic objects.

Pinnate : Leaflets arranged on opposite sides of a common leaf-stalk.

Pleistocene : The latest of the five periods of the Cainozoic Era.

Plesiosaurus : An extinct kind of sea-reptile.

Pliocene : The fourth of the five periods of the Cainozoic Era.

Plumule : The ascending leafy part of a young plant, or growing embryo.

Plutonic : Igneous rocks which have cooled at great depths below the surface of the earth.

Pollen : The fertilizing dust contained in the anthers of stamens.

Pollinium : The pollen masses of orchids.

Polyps : Animals like the hydra or the corals.

Porifera : The sponges.

Proboscis : The trunk which is used for conveying food to the mouth.

Process : In botany or biology, a projection or growth proceeding from the stem or body.

Protozoa : A group of one-celled animals having no body cavity or nervous system.

Pseudopodia : The "false feet" or processes which protozoons use in their movements.

Pteranodon : An extinct flying reptile.

Pterichthys : An extinct fish.

Pterodactyles : Extinct flying reptiles.

Pterygotus : An extinct Crustacean.

Pupa : The chrysalis form of insects.

Pyrites : A sulphide of iron which forms bright, brassy crystals.

Quartz : A crystalline oxide of silicon commonly occurring in veins of rocks.

Quartzite : A sandstone or grit affected by contact with igneous masses, and metamorphosed and hardened by the heat.

Quaternary : Another name for the Pleistocene Period.

Radical : Springing from a point just above the root.

Radiolaria : Marine protozoons which build flinty skeletons, through apertures of which they protrude parts of their bodies in a ray-like manner.

Receptacle : The swelled top of a flower-stalk bearing the flowers of a composite. The support of the parts of a flower.

Reniform : Kidney-shaped.

Reptiles : Animals covered with scales or plates and which breathe entirely by lungs.

Reticulated : Forming a network.

Rhizome : A prostrate stem sending roots into the earth.

Rugose : Wrinkled.

Runcinate : A pinnatifid leaf, like that of the dandelion, the lobes of which point to the base.
Sagittate : Arrow-shaped.
Sandstone : Sand consolidated by a cementing material into a rock.
Schist : Rocks having a foliated structure.
Scion : In botany, a creeping shoot.
Sepals : The leaves or divisions of the calyx.
Sepia : The ink ejected by cuttle-fish.
Serrate : Toothed like a saw.
Sessile : Stalkless.
Shale : Hardened clay, splitting into laminæ or layers.
Sigillaria : A fossil lycopod.
Silica : A mineral occurring in the form of flint, quartz, etc.
Siliceous : Of the nature of silica.
Sill : A layer of igneous material intruded between beds of stratified rocks.
Silurian : The third period of the Palæozoic Era.
Simple : In botany, unbranched.
Sinuate : Having large blunt lobes.
Spatha : A large bract forming an envelope to some flowers when in bud.
Spathulate : Spoon-shaped.
Spicules : Small, variously shaped pieces of carbonate of lime, silica, or horn embedded in the bodies of sponges.
Spores : The reproductive bodies of flowerless plants.
Sport : A monstrosity or freak.
Stamens : The male organs of flowers.
Stegosaurus : An extinct monster, known as "the plated lizard."
Steneosaurus : A Jurassic reptile akin to the existing alligator.
Stigma : The portion of the pistil to which the pollen adheres.
Stigmaria : The roots of the fossil plants called sigillaria.
Stipules : Leaf-like growths at the base of the leaf-stalk.
Stole : A trailing shoot rooting at intervals.
Stratified : Formed in beds, layers, or strata.
Striations : In geology, markings on boulders or rock surfaces caused by glaciers.
Style : The stalk rising from the ovary and bearing the stigma.
Subulate : Awl-shaped.
Teleosaurus : A Jurassic reptile akin to the modern crocodile.
Ternate : Three leaflets arising from the same point.
Tertiary : The Cainozoic Era.
Thalamifloræ : The first sub-class of the Dicotyledonous plants.
Theromorphs : An extinct order of reptiles.
Trachea : A breathing passage.
Triassic : The first of the three periods of the Mesozoic Era.

Trilobites : An extinct order of crustaceans.
Tripinnate : Three times pinnate.
Tuber : An underground fleshy development of the stem, as in the potato.
Tyrannosaurus : An extinct reptile.
Unicellular : One-celled.
Vasculum : A collecting-box for plants.
Viscid : Sticky, tenacious, clammy.
Viviparous : Producing young alive.
Volcanic : Igneous rocks which have cooled at or near the surface of the earth.
Whorl : Leaves, flowers, or organs arranged in a circle round an axis.

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